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Box 2
Item 2-13

Eric Hecox/NCS/BLM/DOI
07/27/2005 02:48 PM

To Kit Muller/WO/BLM/DOI@BLM
cc Dan Muller/NCS/BLM/DOI@BLM
bcc
Subject EMAP and draft monitoring strategy

Kit,

As part of NSTC's involvement in the monitoring review, I have been working on assessing EMAP's applicability. Through this effort, I have been working with Bob Hall at the EPA. I believe you met him and saw a presentation on EMAP during the Albuquerque meeting. He is very excited about applying EMAP to BLM and is interested in building a monitoring strategy for BLM. I (and other BLMers I've spoken with) believe that EMAP can be of particular value and has a lot to offer BLM. However, I do not know the larger picture and cannot determine how interested BLM is in EMAP. Although EMAP is applicable and shows a lot of promise for BLM, it may not be the 'best' approach in the scheme of things. This is something someone with a larger perspective will have to determine.

To help gauge BLM's interest in EMAP, Mr. Hall sent me the below e-mail and attached draft monitoring strategy. It is an example of how EMAP can be applied to BLM's monitoring effort. As he mentions, it is quite rough and would need substantial work, but it serves as an example of what can be done.

Once we have an idea of how interested BLM is in EMAP, further work can be done to fill in the details, make the monitoring strategy more appropriate, and assess the cost. Take some time to look over Mr. Hall's note and the attached document and weight the applicability of EMAP against other monitoring efforts BLM is considering. If it looks like BLM is interested in pursuing EMAP further, NSTC (along with others) can work with Mr. Hall to refine the monitoring strategy. However, if it looks like BLM will be taking a different direction I would hate to take up BLM and EPA's time and resources. I'll wait for your advice and guidance before moving forward.

Thanks for allowing me to be a part of this monitoring effort, and if I can provide any additional information or assistance please let me know.

Eric

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----- Forwarded by Eric Hecox/NCS/BLM/DOI on 07/27/2005 11:27 AM -----

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06/02/2005 02:08 PM

To Eric_Hecox@blm.gov
cc Dan_Muller@blm.gov, Karl_stein@blm.gov, don_prichard@blm.gov
Subject Re: Another BLMer working on EMAP

Eric,

Attached is a very, very draft monitoring strategy. I put this together using some of my other EMAP project

proposal. I played around with the text up to the methods section. From there it's fairly standard stuff. Budget is totally bogus. It's for collecting field data from another project, but it can give you an idea of some costs. Ballpark figures for the collection of new field data - terrestrail assessment is $2000. Streams run around $3000, which includes everything and the kitchen sink. I couldn't really do a budget for you because until we get the objectives, sample design, detection limits, in-kind services (e.g., landscape analysis, site selection, data management, etc.), etc., etc., etc. I could only give you ballpark figures. Any actual costs will be much different, because most, or I should say, all of the costs are in collecting new field data.

Important steps - getting the objectives down. Once the objectives are established setting up a montioring plan (national, regional, local; long- and/or short-term; etc.) is easy. Once we have the monitoring plan I can put a draft Quality Assurance Plan (QAP) together for you. After the QAP we can then play with the sampling protocols - see place holders in Appendices
Everything in the attached is just examples of what can be done. We can mix and match once you objectives are established.

Let me know what you think.

Bob Hall

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Box 2
Item 2-13

BUREAU OF LAND MANAGEMENT

MONITORING STRATEGY [draft]

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Appendix E – Water Quality sampling protocol

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Figure 1. Location map of BLM managed lands.

Figure 2. Location of random sampling locations using an equal number of points within BLM lands

Figure 3. Location of random sampling locations using an equal number of points within BLM lands for Level II Ecoregions.

PROPOSAL SUMMARY

The Bureau of Land Management (BLM) is responsible for managing the nation's public lands, which takes into consideration natural resources such as terrestrial and aquatic wildlife, vegetation and uses such as livestock & recreation. Congress recognized the impact of man's activity has on the interrelations in the natural environment, which include population growth, high-density urbanization, industrial expansion, resource exploitation. Congress further recognized the critical importance of restoring and maintaining environmental quality to the overall welfare and development of human activity. In order to carry out federal policy, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with national policy, to improve and coordinate Federal plans, functions, programs, and resources to the responsibilities as the trustee of the environment for succeeding generations. The Bureau of Land Management (BLM) is responsible attaining and maintaining the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences. BLM is also responsible preserving important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and enhance, or sustain, the quality of renewable resources.

Under the Clean Water Act, land management agencies are responsible for non-point source (NPS) runoff. BLM is responsible for developing a monitoring and assessment program to determine the extent of NPS to the surface waters of the US.

The BLM monitoring strategy seeks to define the spatial distribution of natural resources, develop terrestrial landscape indicators, define reference conditions, identify non-point source (NPS) loadings to streams and examine their effect on aquatic resources. This project will address concerns in the areas of anthropogenic activities on lands under BLM management.

The BLM monitoring strategy is designed to incorporate already existing environmental monitoring and assessment programs. For example, the USEPA Environmental Monitoring and Assessment Program (EMAP) surface water and landscape program, and the US Geological Survey (USGS) National Water Quality Assessment (NAWQA) program. Objectives of this monitoring strategy and proposed coordinated studies is to characterize the terrestrial and aquatic habitats within the boundaries of all BLM managed lands, define reference sites and conditions, and determine potential NPS runoff coefficients. The intent of the study is to determine the level of effort and the indicators needed to develop management strategies for present and future sustainable development of federal resources. This monitoring strategy is designed to assess 100 percent of BLM managed lands as part of a 4-5 year project cycle. Aquatic bioassessment and landscape characterization are cost effective tools to enable characterization of water quality and condition of terrestrial and aquatic biological resources.

This monitoring strategy will provide a data set that can serve as a basis for evaluating anthropogenic change over time, and it can substantially increase BLM's knowledge of terrestrial and aquatic communities. The proposed bioassessment/resource assessment will also

provide much needed information on the condition and ecological integrity in areas of concern and will establish criteria for monitoring/assessment throughout the US. Additional information on the ecology of terrestrial and aquatic communities structures will provide further insight into how these organism are impacted by various physical and chemical parameters. This national monitoring strategy and investigation will also provide information on the biodiversity of present on BLM managed land.

I. BACKGROUND

Need to fill in – past/present/future monitoring demands

II. PROJECT DESIGN

BLM monitoring strategy will have three basic designs – national, regional and local. Assessment of all federal lands will be at the national level. The national assessment will incorporate regional and local scale assessment and will incorporate already existing data from BLM and other federal, state and tribal monitoring programs. BLM EMAP program will select sampling sites based on the following national objectives:

- Extent and integrity of terrestrial resources (e.g., range land, wetlands, riparian zones)
- Spatial distribution of native wildlife habitats and invasive communities
- Water quality, aquatic communities
- Define terrestrial and aquatic reference, or best, conditions and reference sites
- Identify anthropogenic impacts to terrestrial and aquatic resources (oil & gas, mining, grazing, recreation, etc.)
-

Regional and local monitoring programs will incorporate national randomly selected sites and long term fixed stations sites into regional and local assessment. Data collection of vegetation, water, soil and sediment chemistry, range, lentic and lotic parameters will be incorporated into the national assessment. The study area(s) of interest are lands managed by BLM (Figure 1). Task 1 will identify and evaluate landscape indicators to conduct a comparative landscape assessment and determine any ecological changes occurring from human influence. Task 2 will review and identify landscape and aquatic models, which utilize the most appropriate statistical methods for the analysis of wildlife and habitat (e.g., water and sediment chemistry) parameters using aquatic biota and landscape indicators. Task 3 will be to determine baseline conditions, aquatic resources and identify reference sites within the study area. Task 4 will collate and incorporate existing BLM analog data into a digital format as part of the monitoring data management strategy. Task 5 will develop a management tool for implementing Best

Management Practices (BMP) based on cost benefits, which will include parameters from tasks 1-4. For example, the determination of load allocation within a watershed or sub-watersheds and/or particular stream reach(es). Each phase can be implemented in sequence or concurrently depending on funding and regional participation.

Figure 1. Location map of BLM managed lands.

Objectives

This proposed federal land bioassessment study will be 4-5 year project dependent on funding. Funding requirements and future research areas will coincide with priority management units (e.g., ecoregions, allotments, watersheds, etc.). The proposed study will initiate a two year biological assessment of lands under federal management in the Humboldt River and Snake River drainages in northeastern Nevada. The objectives of regional and local studies are:

1. Assess the condition of aquatic resources (macro invertebrates and fish) within the study area

2. Identify landscape indicators that represent natural and human factors which have an effect on water quality

3. Establish baseline values for water, soil and sediment chemistry parameters and toxicity, determine trend relationships for individual chemical parameters, and estimate loading rates related to time (kg/yr) and unit area (kg/ha) for each sub-watershed

4. Define terrestrial and aquatic reference conditions for grazing allotments, land use objective, and perennial streams and rivers

5. Quantify nutrient and metal nonpoint source loads from the various land use categories identified in objective 2.

III. SAMPLING DESIGN

The BLM national monitoring strategy will identify baseline conditions and reference sites BLM managed lands using the EMAP random sampling design. An Index of Biological Integrity (IBI) and Index of Habitat Integrity (IHI) for terrestrial (e.g., vegetation, wildlife, threatened and endangered species) and aquatic fish and invertebrates will be generated. Indexes will used to assess different ecological conditions. For example, high gradient/elevation/cold water streams effected predominantly by mining and logging activities, and for low gradient/elevation/warm water areas where impacts have been documented by several sources.

A random sampling design will be employed to determine site locations within the watershed (Stevens and Olsen, 1999). A total of 150 sites per year will be allocated between

terrestrial and aquatic resources (figure 2 and figure 3). Aquatic sites will incorporate range assessments, where appropriate.

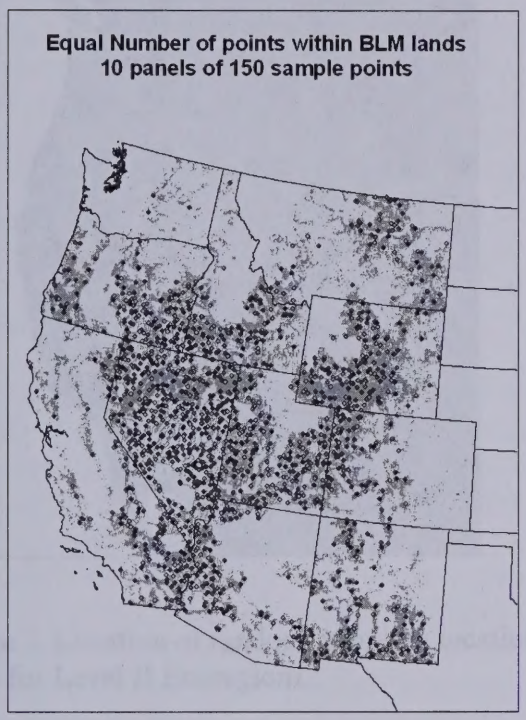

Figure 2. Location of random sampling locations using an equal number of points within BLM lands.

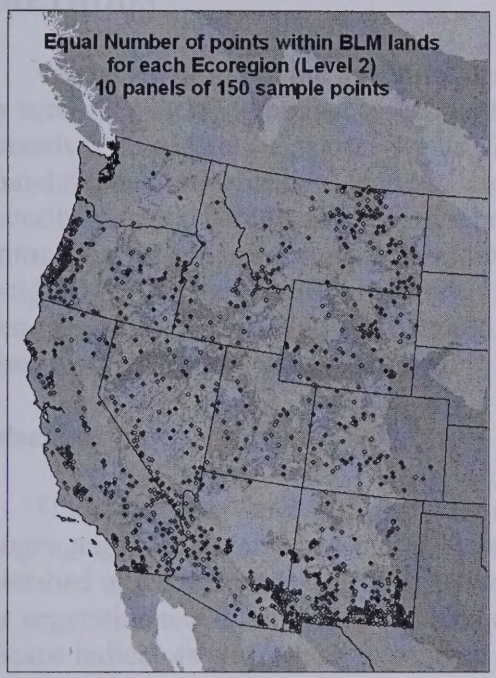

Figure 3. Location of random sampling locations using an equal number of points within BLM lands for Level II Ecoregions.

The actual number of sites assessed is based on funding resources. Actual number and location of sites will be determined upon consultation with USEPA statisticians. Field crews will collect biological, physical habitat and chemical data during identified index periods (e.g., stream low flow during July and August).

Sampling sites are selected using a random tessellation stratified design (Stevens and Olsen, 1999; Stevens, 1997). The tessellation stratified design confines the sample site selection to ensure the target population represents the spatial coverage of the study area. For example, the target population is streams. Using the National Hydrographic Dataset (NHD), Strahler Order 1-4 as the sampling frame for identifying target population streams (Horn and Grayman, 1993) to achieve an approximately equal expected sample size across stream order and across basins. The sample design is weighted by stream order categories to ensure sampling will occur in the higher order streams (Hall, et al. 1998). For terrestrial assessment a spatial boundary (e.g., grazing allotment, level IV ecoregion, etc.) is used to identify a particular target population.

Also, to quantify loads from non-point sources a long term fixed station water quality monitoring sites will be selected (e.g., to represent mining and grazing impacted streams). These sampling sites will be identified from the data collected from the randomly selected sites.

IV. METHODS

Characterization of the terrestrial and aquatic organisms and habitats within the describe study area(s). Watershed habitat assessment will provide information on stream condition such that trends from natural (ie., storm events, flow, etc.) and human influenced stressors (ie., impoundments, channelization, land use, etc.). These data can be determined spatially and temporally. Aquatic habitat, macroinvertebrate and fish diversity and population structure will be determined in 1st-nth order streams found within the study area/watershed. The proposed investigation will determine if measures of fish community structure correlate with water and habitat variables. The relationship between water and habitat variables and the general condition and health of fish will also be examined.

Landscape

Understanding watershed characteristics will help in the identification and interpretation of biogeographical patterns in biological communities (Fitzpatrick, et al., 1998). To characterize a watershed or a stream it is necessary to identify the geologic, geomorphologic, hydrologic, land cover vegetation and distribution, and land use (figure 2). The first step is to identify a set of landscape indicators with which to conduct a comparative landscape assessment on the sub-regional study areas. The landscape monitoring and assessment approach involves the analysis of spatially explicit patterns of, and associations between ecological characteristics such as soils, topography, climate, vegetation, land use, and drainage pathways, and interprets the resulting information relative to ecological conditions on areas ranging in size from small watersheds (a few hundred hectares) to entire basins (several million hectares) (Foreman 1990, O'Neill et al. 1994, Kepner et al. 1995, Jones et al. 1997.)

Five characteristics distinguish a landscape monitoring and assessment approach from most traditional field- or site-based monitoring programs:

(1) it involves analysis of spatially explicit patterns of ecological characteristics (e.g., forests near streams) to interpret ecological conditions;

(2) it applies the concept from the field of landscape ecology that changes in landscape patterns result in changes in fundamental ecological processes, including fluxes in energy, biota, materials and nutrients, and water;

(3) it applies the concept of ecological hierarchy theory in analyzing the consequences of landscape change on ecological resources and processes at multiple scales;

(4) it utilizes digital maps or coverages of biophysical (e.g., soils, vegetation, topography, and climate) and human use (e.g., land use, population change) characteristics to analyze

and interpret spatially explicit landscape patterns relative to ecological condition; and

(5) it includes rather than excludes humans as part of the environment.

The fundamental basis for this type of approach is that spatially explicit changes in landscape pattern result in changes to ecological processes from which important ecological goods and services are derived and sustained (Turner 1989, Foreman 1990, Figure 1). For example, losses of forested riparian habitats in a watershed reduce that watershed's ability to filter sediment from overland surface flows (Karr and Schlosser 1978; Lowrance et al. 1984, 1985; Peterjohn and Correll 1984). This results in reduced water quality in the streams of that watershed. Similarly, clear-cutting of forests on areas with steep slopes results in soil loss which in turn can decrease the likelihood of sustaining harvestable forests on the those areas and increase sediment loadings to streams (Lee 1989; Franklin 1992).

Following is a list of landscape indicators being evaluated for use in the EMAP Western Pilot (Jones, et al., 1997). For this study these indicators will be assessed to meet the needs of the project objectives.

Watershed land use, land cover, and development indicators

UINDEX: Human use index (proportion of watershed area with agriculture or urban land cover)
NINDEX: Natural land cover diversity (heterogeneity of watershed area relative to land covers which are not agriculture or urban)
RDDENS: Road density (average number of kilometers of roads per square kilometer of watershed area)
IMPERV: Amount impervious surfaces (roads, parking lots, urban factors)
RIPFOR: Proportion of total streamlength with adjacent forest land cover
RIPAG: Proportion of total streamlength with adjacent agriculture land cover
STRD: Proportion of total streamlength that has roads within 30 meters
DAMS: Number of impoundments per 1000 kilometers of stream length
CROPSL: Proportion of watershed with crop land cover on slopes that are greater than three percent
AGSL: Proportion of watershed with agriculture land cover on slopes that are greater than three percent
PSOIL: Proportion of watershed with potential soil loss greater than one ton per acre per year
Surface mine impacts: Indicator describing how the mine density and distribution in a watershed, and their proximity to streams affect water quality. Indicator will be stratified by mine type.
Point source (NPDES) index: Density and diversity of pollution discharges in watershed (or sub-region) (stratified by types of contaminants and media of release + modeled T&F)
WATSTOR: Amount of surface water storage capacity for watershed (total area of lakes rivers, wetlands areas)
Feedlots: index of feedlot locations and densities (CAFO program)

Ownership: land ownership (GAP, RLM ALMRS, ICBEMP)
T & E species metrics: Distribution of biodiversity relative to conservation lands (similar to GAP mission), vulnerability of T&E species to disturbance
Rangeland disturbance: terrestrial indicator distinguishing between natural and disturbed grasslands/rangelands ©
Drought index: not defined
Weather patterns: not defined

Forest indicators (may be modified to accommodate rangelands and other arid land-covers in the West)

FOR%: Percent of watershed area that has forest land cover
FORFRAG: Forest fragmentation index
EDGEx: Proportion of watershed area with suitable forest edge habitat (where x is scale)
INTx: Proportion of watershed area with suitable interior forest habitat (where x is scale)
INTALL: Proportion of watershed area with suitable interior forest habitat at three scales
FORDIF: Departure of the largest forest patch size from the maximum possible for a given amount of anthropogenic land cover

Remotely-sensed vegetation indicators

NDVIDEC: Decrease in normalized difference vegetation index from 1975 to 1990
NDVIINC: Increase in normalized difference vegetation index from 1975 to 1990
NDVITOT: Total change in normalized difference vegetation index from 1975 to 1990
1STDEC: Difference between observed and expected decreases in normalized difference vegetation index from 1975 to 1990 in first–order stream regions (stream order criteria may be different in West)
1STINC: Difference between observed and expected increases in normalized difference vegetation index from 1975 to 1990 in first–order stream regions (stream order criteria may be different in West)
1STTOT: Difference between observed and expected total change in normalized difference vegetation index from 1975 to 1990 in first-order stream regions (stream order criteria may be different in West)
NDVI3%: Proportion of watershed with normalized difference vegetation index decreases from 1975 to 1990 on slopes greater than three percent (slope criteria may be different in West)
NDVIDIV: Spatial and temporal diversity in the NDVI signal across landscapes. Developmental indicator of land-cover classes (C3 v C4 vegetation) and their response to stress (drought or grazing).
Surface roughness: indicator the presence of vegetation - not well defined

Chemical loadings

STNL: Potential nitrogen loadings to streams
STPL: Potential phosphorus loadings to streams

Riparian indicators

Riparian patchiness: Greenness patch dynamics to identify streambank stability at sub-pixel scale (could be indicator of grazing impacts of stream riparian)

Shading: Amount of stream shading (and subsequent temperature regulation) attributable to topography and riparian vegetation

Indicators of riparian "reference" conditions: not well defined

Hydrologic connectivity: index of "lateral plumbing" along streams as indicator of vulnerability (phase 3 or 4, i.e. applied at large areas)

Linked landscape/WQ indicators: nested indicator linking remote sensing based analysis with EMAP Surface Water's analysis)

Channel geomorphology: Multi-resolution identification of channel geomorphology and changes in geometry

Runoff characteristics: flooding characteristics, stream flow regime (or surrogates)

Cow grazing intensity indicator: impacts on riparian vegetation, erosion, bank stability; derived from agriculture and land use data

Description of selected Landscape Indicators (Jones, et al., 1997)

Human Use Index (UINDEX)

Two different methods will be used to create the two maps of the human use index. The surface map for the Great Basin region will be produced by using a spatial filter. The window size will be about 65 hectares and contained 729 pixels in a 27x27 pixel window. The window will be moved one pixel at a time across the land cover map. At each step, the number of pixels that had agriculture or urban land cover will be counted. Dividing this sum by the number of pixels in the window (729) yielded the index value which will then be mapped at the location corresponding to the center of the window. A second spatial filter will then be applied to "smooth" the surface map. The smoothing filter will find the median index value in 9x9 pixel windows (about 7 hectares). The final map will be shown at 7–hectare resolution. The watershed map will be produced by using a cookie–cutter procedure to extract the land cover information for each watershed separately. The number of pixels with agriculture or urban land cover will then be counted in each watershed, and the total will be divided by the total number of pixels for a given watershed to yield the per–watershed index value.

Road Density (RDDENS)

The United States Geological Survey road maps are very detailed maps which are available as digital line drawings. To create the surface map of relative road density, the line drawings will be first converted to raster images (or bitmaps) with a resolution of 90 meters. That is, each 90–meter by 90–meter square in the region that contained at least one road segment will be coded as containing a road. Then a spatial filter will be applied to this 90–meter resolution map. The window size will be approximately 1 km 2 and contained 121 pixels in a 11x11 pixel window. The window will be moved one pixel at a time across the land cover map.

At each step, the number of pixels that are coded as containing at least one road segment will be counted. The road density score will be obtained by dividing this sum by the number of pixels in the window (121), and this score will then be mapped at the location corresponding to the center of the window. This procedure tends to emphasize the importance of the first occurrence of a road in a given location, and to give less weight to subsequent occurrences.

To create the watershed map of road density, a different procedure will be used. The line drawings representing all roads will be clipped using the watershed boundaries, so that a per–watershed value could be calculated. The total length of roads in each watershed will be divided by the total area of the watershed. The resulting value represents road density as road length (kilometers) per unit area (square kilometers).

Landscape Units

The land cover map will be analyzed using the spatial filtering technique. The window size will be about 590 hectares and contained 6,561 pixels. The window will be moved one pixel at a time across the land cover map. At each step, counts will be made of the number of pixels that were forest, agriculture, and urban in the window. Then, a landscape unit type will be assigned to the location at the center of the window by using rules which are described in the text. To simplify the resulting map, a majority–rule spatial filter will be applied and the resolution will be reduced to about 7 hectares. The majority–rule filter will examine all landscape pattern types within 7–hectare windows and assign the most common type to the whole window.

Forest and Agriculture Land Cover Along Streams (RIPFOR, RIPAG)

Maps of forest and agriculture land cover along streams will be created by using the overlay technique. The map of streams will be converted to a raster format with 30–meter pixels. This version of the streams will be overlaid on the land cover map to determine the stream length that flowed through forest and agriculture land cover. The length of streams flowing through forest and agriculture land cover, respectively, will be divided by the total length of streams in each watershed to arrive at the index value. A 30 meter pixel size will be used because it is consistent with the pixel size of the land cover map. The proportions would change with different stream pixel sizes, depending on the amount of forest and agriculture land cover in the riparian zone defined by the pixel size.

Roads Along Streams (STRD)

The procedure will be similar to that used for the preceding indicators. Road and stream maps will be converted to a raster format with 30 meter pixels, and then overlaid. The number of pixels where both a road and a stream occurred will be divided by the total number of stream pixels in the watershed.

Impoundment Density (DAMS)

The U.S. Geological Survey defines large dams as those that are able to store at least 5,000 acre–feet of water. The source data will be converted into a map of point locations, and overlaid on the watershed map. The number of dams in each watershed will be then divided by the total stream length for the watershed to estimate the density of impoundments. The density estimate is expressed as the number of dams per 1,000 kilometers of streams.

Crop Land and Agriculture Land on Steep Slopes (CROPSL, AGSL)

Agriculture on steep slopes was mapped by overlaying the slope map and the land cover map. Percent slope is calculated from the U.S. Geological Survey digital elevation model (DEM) as the vertical rise in elevation per horizontal distance traveled. After overlaying the two maps, the proportion of watershed area that is crop, or agriculture, on slopes greater than three percent was found by using the cookie–cutting technique. The three percent threshold value will be taken from U. S. Department of Agriculture studies that classified slopes into six categories. Based on this classification, slopes greater than or equal to three percent have a greater risk of soil erosion.

Potential Nitrogen and Phosphorus Loadings to Streams (STNL, STPL)

To estimate total nutrient export potential on a per–watershed basis, the land use/land cover data is clipped to the particular assessment units (i.e., HUCS). The land cover types are chosen, which will contribute to N and P loading. The area is calculated and the reported median coefficients for comparable agricultural uses (Young, et al., 1996, in the Journal of Environmental Management) are multiplied by the amount of land cover in the agriculture land cover classes. This provides a value of kg/ha/yr.

A literature survey of North American nutrient export studies provided coefficients for estimated export (kg/ha/yr) for nitrogen and phosphorus under different types of land uses. The coefficient–times–land use model was developed in 1980 for the United States Environmental Protection Agency by Rechow and others (US EPA 440/5–80–011, Washington, DC). The coefficients reported for nitrogen varied from 2.6 to 6.2 kg/ha/yr, with a median value of 3.9 kg/ha/yr. The values reported for phosphorous ranged from 0.3 to 1.5 kg/ha/yr, with a median value of 0.7 kg/ha/yr.

Soil Loss Potential (PSOIL)

The Universal Soil Loss Equation (USLE) estimates soil erosion from agricultural lands as a function of rainfall, soil type, slope, and land cover characteristics. The basic equation is: A = R * K * LS * C * P, where A is long–term average annual soil loss (tons/acre/year), R is the long–term erosive potential of rainfall, K is the soil erodibility factor, LS is the length–slope factor, C is cover and management factor, and P is the support management factor (e.g., strip cropping, buffer–strip cropping, grazing, etc.). Representative values for the Basin and Range

Province will be created for each parameter in the model (rainfall erosive potential, soil erodibility, length–slope, cover and support management) on a pixel–by–pixel basis. R factor values will be taken from USDA Agricultural Handbook 537, soil erodibility was taken from USDA, Soil Conservation Service digital soil maps, and length–slope values will be taken from USGS DEM data. The area of each watershed with the potential for soil losses greater than 1 ton per acre per year will then be found by summing the number of pixels in each watershed that exceeded this threshold value. The indicator is the proportion of the watershed above that threshold value.

Forest Land Cover (FOR%)

The cookie–cutter procedure to extract the land cover information will be applied to each watershed separately. The number of pixels with forest land cover will then be counted in each watershed, and the total will be divided by the total number of pixels for a given watershed to yield the per–watershed index value.

Forest Fragmentation (FORFRAG)

Forest fragmentation will be assessed at a resolution of about one–tenth hectare by using a version of the land cover map which had only two lumped categories, forest and non–forest. The fragmentation statistic measures the probability that a randomly selected forested spot in a watershed is not adjacent to another forested spot. Higher values indicate higher fragmentation. The statistic will be calculated separately for the forest cover within each watershed in the region, rather than using a sliding window technique.

Forest Edge Habitat (EDGE7, EDGE65, EDGE600)

Forest edge habitat differences among watersheds will be assessed by the sliding window technique. The fragmentation indicator described above will be used, but calculated in a small window that will be placed within a watershed. If the calculated indicator value exceeded one–half the maximum value for that amount of forest, then the center of the window will be marked as suitable edge habitat. After moving the calculation window throughout the watershed, the proportion of the watershed that will be labeled suitable will be calculated and used as the indicator value. The exact window sizes used will be 7.29ha, 65.61ha, and 590.49ha.

Forest Interior Habitat (INT7, INT65, INT600, INTALL)

The sliding window technique will be used to assess interior forest habitat. The proportion of forest cover will be calculated within a window that will be placed within a watershed. If the proportion of forest exceeded a threshold value of 90%, then that place in the watershed will be considered to be suitable interior habitat. After placing the calculation window everywhere in a watershed, the proportion of the watershed that is suitable habitat will be

determined. These proportions will then be used to rank the watersheds. The proportion of watershed area supporting three scales of interior forest habitat will be calculated as the proportion of pixels in a watershed that exceeded the threshold value for all three window sizes (7.29 ha, 65.61 ha, and 590.49 ha).

Departure of the Largest Forest Patch Size from the Maximum Possible for a Given Amount of Anthropogenic Cover (FORDIF)

Each forest patch will be determined with a routine that finds all adjacent pixels of the same cover type and then assigns them a unique value, and also retains the original land cover value. There are as many unique values as there are patches in the watershed. From these data, we will create a file of forest patches and sorted it to find the largest forest patch. A proportion will be calculated using the watershed area as the denominator. The proportion was then subtracted from 1.0 minus the U-index to derive the indicator value.

Calculation of NDVI and its Change (NDVIDEC, NDVIINC, NDVITOT)

NDVI is calculated from satellite spectral reflectance data in the red and infrared wavelengths, using the equation: NDVI = (infrared – red) / (infrared + red). The reason that NDVI in particular, and all vegetation indices in general, are able to distinguish plants from all other surface features is that vegetation reflectance jumps dramatically in the infrared region of light, and is strongly absorbing (not reflective) in the red region. For vegetation, typical infrared and red values might be 0.8 and 0.1 respectively, giving an NDVI value of 0.78. For other earth surface features, the infrared and red reflectance values are more similar. Because of this, the numerator tends to be close to zero (or even slightly negative) while the denominator tends to double. NDVI values for barren surfaces are typically close to or less than zero. Once the NDVI maps are made for each date, differences are calculated simply by subtraction. The resulting differences range negative to positive, centered on zero (0). Values close to zero indicate that there has not been a change in land cover. Calculating the difference of temporal satellite images usually yields an approximately normal distribution. For a normal distribution, about 70% of the values are within one standard deviation of the mean, which is zero in this case. Previous research has shown that one standard deviation is an accurate threshold to distinguish change from no change. We chose one standard deviation as our change/no change threshold.

NDVI Change within Watersheds (1STDEC, 1STINC,1STTOT)

Observed values for the three aspects of vegetation change come simply from the change that occurred in the first order stream region. Expected values come from the product of the change over the whole watershed multiplied by the proportion of the watershed in the first order stream region. It will be necessary to choose a threshold to decide if a calculated difference between observed and expected is significant.

NDVI Loss on Steep Slopes (NDVI3%)

Vegetation loss on slopes greater than 3% was created using the overlay technique. The NDVI change data will be overlaid upon the USGS DEM data which will be reclassified into percent slope. Proportional values were calculated by dividing the amount NDVI loss, gain, or total change by total watershed area.

Reconnaissance - Office and Field

The main objectives of reconnaissance are to:

1. Locate the sample site before the actual sampling begins;
2. Obtain permission to access the site from landowners (including State and Federal resource agencies);
3. Estimate the difficulty of sampling a particular reach (i.e., length of hike into reach, amount of large woody debris);
4. Determine if any restrictions to sampling might be applicable (ie., wilderness area).

Stream sample sites were chosen from the blue lines stream network represented on 1:100,000 scale USGS maps following a systematic randomized design developed for EMAP stream sampling (Stevens and Olsen, 1999, Stevens, 1997). Sample sites were then marked with an X on finer-reduction 1:24,000 scale USGS maps. This spot is referred to as the X-site.

Reconnaissance for this study will be done in a two-step process. Step 1 - office evaluation, and Step 2 - field evaluation of the selected sites. Sample sites are selected from an RF3 sample frame (Stevens, 1994) and mapped onto transparent overheads at 1:62,500 map scale, which is equivalent to a 7.5 min USGS quadrangle map sheet. Each overhead shows the random sampling site location, latitude, longitude, county, and 7.5 min. USGS topographical map name. Each overhead is overlain onto the appropriate map sheet to determine altitude and directions to the site.

Sites are discarded if they reside in steep and inaccessible terrain (Hall, et al., 1998). The remaining sites are selected for further field reconnaissance to verify the presence or absence of water, wadeability, accessibility, safety, or if ownership could be determined (Hall, et al., 1998). A major portion of the sites field visited could be viewed without prior landowner permission (Hall, et al., 1998). Upon reaching a site, it is determined whether the site will be sampleable or non-sampleable during the designated index period. The site is considered non-sampleable if it is:

! wider than 30 meters
! potentially dangerous
! dry
! no longer existed
! difficult access, or no visible access point

If the site was determined to be sampleable, then the approximate width, depth, directions, possible site contacts, and any additional comments are noted.

Office Reconnaissance Methods

The methods used for evaluating stream habitat at the various scales combine existing information from sources such as GIS data bases and maps with field-controlled data on instream and riparian features. These methods provide a basis for national consistency yet allow flexibility in habitat assessment at all scales of the hierarchy (Fitzpatrick, et al., 1998).

The term "basin" denotes the area drained by all surface waters located upstream of a selected site. The development of stream habitat is influenced by spatial factors, which include physiographic province, geology, climate, etc. (Fitzpatrick, et al., 1998). The 'basin unit' is useful for characterizing the environmental setting of selected sites (Fitzpatrick, et al., 1998). Evaluation of basin-wide natural and human factors will enhance comparative analysis of biogeographic patterns in relationship to biological communities (Fitzpatrick, et al., 1998; Karr and Chu, 1999).

The GIS data bases are a primary component of basin characterization. For the aggregation of data among study units, data related to basin-level variables must be gathered. For analysis of data at the study-unit level, local coverage maps and aerial photographs generally provide better resolution per data base (Hall, et al., 1998). Also, nondigital coverages may provide valuable information for individual study units. Thus, two levels of data-base coverage are required for basin characterization to ensure the use of the most complete basin-level information at the greatest resolution for individual study units, as well as to allow comparisons of basin characterizations among study units (reference, Meador, et al., 1993).

A basin characterization is conducted at fixed and synoptic sites using the basic instructions outlined below as adapted from Meador, et al., 1993.

1. Study unit: Use the watershed name or study ID.
2. Date Record the date as month, day, year.
3. Station name: List the EMAP station name, or create one (ie., river name, unnamed ditch, etc.)
4. Station identification number: List the EMAP station identification number for the site.
5. Investigator(s): Self explanatory.
6. Location of site: Briefly describe the direction to the site location. Record any USGS (ie., bench marks, etc.) or thematic information from the topographic sheets (ie., latitude and longitude, USFS or BLM land, etc.).
7. Drainage area: Delineate drainage basin boundaries on a 1:24,000-scale 7.5-minute quadrangle map (7.5' map) and calculate the drainage area of the basin upstream of the sample site. For items 7 through 13, if the information cannot be obtained realistically from a GIS database (eg., DEM's), or 7.5' quad sheets, then collect the data at 1:250,000-scale resolution, or any

other small quad sheet.

8. Drainage density: Measure the cumulative length of all perennial streams and canals in the basin upstream of the reference location using RF3, or as noted on a 7.5' quad sheet. Then divide the cumulative length by the drainage area to calculate drainage density.
9. Drainage texture: Drainage texture is an expression of the closeness of spacing of stream channels in the basin upstream of the reference location and is calculated by determining the basin contour with the most crenations, as noted by visual inspection of a 7.5' map. Following that contour, determine the number of channel crossings. Divide the number of stream channel crossings by the length of the perimeter of the basin (Meador, et al., 1993).
10. Drainage shape: To determine drainage shape, measure the basin length, square it, and divide it by the drainage area, using a 7.5' map.
11. Stream length: Measure the length of the stream from the headwaters to the reference location, as noted on a 7.5' quad sheet.
12. Basin relief: Determine the highest elevation in the basin minus the elevation of the reference location as noted on a 7.5' quad sheet.
13. Storage: Determine the cumulative area of the drainage that is composed of stored water, including reservoirs, lakes, ponds, swamps, and wetlands, using a 7.5' quad sheet.
14. Ecoregion: Record up to three of the spatially dominant ecoregions for the basin upstream of the reference location and the percentage of the basin that each occupies (omernik, 1987). Omernik (1987) identified relatively homogeneous ecological regions of the United States based on regional patterns of spatially variable combinations of land use, mineral availability (soils and geology), potential natural vegetation, and physiography. Ecoregioins have been compiled at two map scales, a national map at 1:7,500,000-scale resolution and regional maps at 1:2,500,000-scale resolution. State maps may also be available. Record the local coverage scale of the highest resolution (ie., largest map scale) available.
15. Physiographic province: Coverage of a national map of physiographic provinces is available as a GIS data base and is derived from 25 physiographic provinces representing distinct areas that have common topography, rock types and structures, and geologic and geomorphic history. Record up to three of the spatially dominant physiographic provinces for the basin, upstream of the reference location, and the percentage of the drainage area that each province occupies. Record the local coverage scale of the highest resolution.
16. Land Use: Use the Geographic Information Retrieval and Analysis System (GIRAS) data base to record land use. GIRAS data are based on the Anderson classification system (Anderson and others, 1976), which uses four-letter codes to describe a two-stage hierarchy of land use.
    For example:

Level I

UR	URBAN OR BUILT-UP LAND	
	Level III	
	Re	Residential
	Co	Commercial and services

	In	Industrial
	Ic	Industrial and commercial complexes
	Tr	Transportation, communications, and utilities
AG	AGRICULTURAL	
	Ci	Cropland-irrigated
	Cn	Cropland-non-irrigated
	Pa	Pasture
	Or	Orchards, groves, vineyards or nurseries
	Fe	Confined feeding operations
RA	RANGELAND	
	He	Herbaceous
	Sh	Shrub and brush
FO	FOREST LAND	
	De	Deciduous
	Ev	Evergreen
WE	WETLAND	
	Fo	Forested
	Nf	Non-forested
BA	BARREN LAND	
	Ds	Dry salt flats
	Sa	Sandy areas
	Ex	Bare exposed rock
	Sm	Strip mines, quarries, and gravel pits
	Tr	Transitional areas

Using the abbreviations listed above, record up to three of the spatially dominant Level II land uses and the percentage of the basin upstream of the sample site occupied by each. The national coverage scale is 1:250,000). Record the local coverage scale of the highest resolution available.

17. Geologic type: A national map of bedrock geology at 1:2,500,000-scale resolution is available from GIS data bases (Note: some states may have high resolution data, eg., Nevada). Identify up to three of the spatially dominant geologic rock units (units are based on age and kind; see King and Beikman, 1974) within the basin and report the percentage of the basin upstream of the sample site occupied by each (Meador, et al., 1993). The national coverage scale is 1:2,500,000. Record the local coverage scale of the highest resolution available.
18. Soil type: Two soil-type data bases are available through the Natural Resources Conservation Service (NRCS) (formerly known as Soil Conservation Service) - National Soil Geographic Data Base (NATSGO) and the State Soil Geographic Data Base (STATSGO). Each represents a different map resolution. Each data base is linked to soil interpretations, which provide information on the extent and properties of the soils. Attributes include:
    1. particle-size distribution,

2. bulk density,
3. available water capacity,
4. soil reaction,
5. salinity,
6. percentage of organic matter.

The NATSGO data base provides a general description of soils, based on major land-resource area boundaries developed from State general soil maps. The NATSGO map is available in ARC/INFO format at 1:7,500,000-scale resolution. The STATSGO data base is derived from soil survey maps. Where soil surveys are unavailable, geology, topography, vegetation, and climate data are used with satellite imagery to classify soils. These data are compiled by State at 1:250,000-scale resolution. Identify up to three of the spatially dominant soil types within the basin upstream of the sample site and report the percentage of the drainage area occupied by each (Meador, et al., 1993). The national coverage scale is 1:7,500,000, and the local coverage scale is 1:250,000 for STATSGO data are provided.

19. Potential natural vegetation: Potential natural vegetation is defined as vegetation that would exist today if man were removed from the scene (Kuchler, 1970). Characterizing potential natural vegetation provides important baseline information for evaluating the influence of human activities on vegetation within a basin (Meador, et al., 1993). National coverage data on potential natural vegetation is available from GIS data bases at 1:3,200,00-scale resolution. Record up to three of the spatially dominant types of potential natural vegetation for the basin upstream of the sample site and the percentage of the drainage area that each occupies. The national coverage scale is 1:3,100,000; record the local coverage scale of the highest resolution available.
20. Wetlands: The U.S. Fish and Wildlife Service's National Wetlands Inventory is designed to determine the status of and trends in wetlands throughout the United States (Meador, et al., 1993). Wetlands are defined on the basis of plant types, soils, and frequency of flooding. The map is structured using a hierarchical classification, with the highest levels described as Marine, Estuarine, Riverine, Lacustrine, or Palustrine (Meador, et al., 1993). Approximately 70 percent of wetlands in the United States have been mapped at 1:24,000-scale resolution. Approximately 20 percent of compiled 1:24,000-scale resolution maps have been digitized and are available in the Map Overlay Statistical System (MOSS) format (Meador, et al., 1993). Identify up to three of the spatially dominant wetland types within the basin upstream of the sample site and report the percentage of the drainage are occupied by each (Meador, et al., 1993). The national coverage scale is 1:24,000. Record the local coverage scale of the highest resolution available.
21. Mean annual precipitation: Use National Weather Service information to record mean annual precipitation for the basin. Methods for calculating mean annual precipitation can vary among sites. Therefore, record how mean annual precipitation was calculated for the basin.

Field Reconnaissance Methods

Crews should use all available means to insure that they are at the correct site, as marked on the map including; 1:24,000 USGS map orienting, topographic landmarks, county road maps, and global positioning system (GPS) confirmation of site latitude and longitude using the reconnaissance information conducted in the office. Upon finding the X-site, fill out the R-EMAP Location Data Input Form (Lazorchak and Klemm, 1997). The latitude/longitude of the site will be listed on the stream information sheet that will be available to the crews for each sample sites.

Record the latitude/longitude as displayed on the GPS for the X-site on the form. Also record the pertinent GPS data on strength of signal (2-D or 3-D fix) in the appropriate box on the field form. If possible, wait for the GPS to get a 3-D fix. This might require moving the GPS to a more open area near the X-site (GPS works on line of sight to orbiting satellites). If the given latitude/longitude and the GPS latitude/longitude differ by more than 10 seconds, double check that you are at the correct site. Give a detailed description of the directions to the stream site in the comment section of the form, use additional pages, if necessary. It is hoped that R-EMAP, or other programs, will be able to revisit the exact same sites at some point in the future.

Determining Stream Site Status

Not all chosen sites will turn out to be streams. On the basis of previous synoptic surveys, the maps used in the office reconnaissance are far from perfect representations of the stream network. A significant part of EMAP is the estimation of the actual extent of streams in the area. Once the crews have reached the marked sample point, evaluate the X site and place it into one of the following categories. The primary distinction is that the Nontarget categories have no stream channel or are too deep to wade, the Target categories have a definable stream channel. This information will be recorded on the Reconnaissance Form.

Nontarget

1. No stream Channel (map error) - Examination of the X-site showed no water body or channel.

2. Impounded stream - Stream is submerged under a lake or pond due to man-made or natural (e.g., beaver dam) impoundments. If the impounded stream, however, is still wadeable, record the stream as Altered and sample the stream.

3. Marsh/Wetland - Standing water but no defineable stream channel. In cases of wetlands surrounding a stream channel, define the site as Target but restrict sampling to the stream channel.

4. Unwadeable Stream - A stream too deep to be safely sampled by wading following our current protocols. If over half of the reach n wadeable, classify the reach as unwadeable and do not sample it. If more than half of the survey reach is wadeable (e.g., only a couple of deep pools) classify the reach as target and sample what can be safely sampled. Before making this

determination, evaluate whether you expect the flow to drop between now and sampling time.

NOTE: In all cases, evaluate the site at the X0site, don't "find" another spot to sample.

Target

1. Regular Stream - Sampleable stream with our current protocols.

2. Intermittent Stream - Flow of water is not continual at the site but the channel is wet.

3. Dry Channel - No water in the channel during the index period.

4. Altered Channel - Stream channel does not appear the way # is marked on the map. However, there is a stream in the field that appears to be the stream marked with the X-site on the map. An example would be a channel rerouting following a flood event that can cut-off a loop of stream. Position a new X-site at the same relative position in the altered channel. make careful notes and sketches of the changes on the Reconnaissance form.

Inaccessible

1. Physical Barriers - If you are physically unable to reach the X-site because of heavy wetlands, steep gorge or other barrier that prohibits safe entry, check off "NO" on the stream sampled box on the site verification form and explain why in the explanations field.

2. No Permission - If you are denied access to the site by the landowner check off "NO" on the stream sampled box on the site verification form and explain in detail in the explanations field.

Record the site class and pertinent site verification information on the R_EMAP Location Data Input Form (Lazorchak and Klemm, 1997). If the site is in one of the target classes, schedule it for sampling. If the site is nontarget or inaccessible, the site visit is complete and do not schedule it for further sampling.

Each visit to a possible site is informative. If time permitting crews will fill out a RBP Habitat sheet for the site. If access to the stream is inaccessible without landowner permission obtaining the primary components (Plafkin, et al., 1989) of the RBP habitat will be difficult. Record as much information as possible so it can be correlated to the landscape and habitat characterization done in the office reconnaissance.

Flow Models

The US EPA has promoted watershed assessment and integrated analysis of point and nonpoint sources. As part of a watershed assessment the state samples the river systems to identify the types and concentrations of pollutants. In most cases the limiting factor for a water

monitoring program is funding resources. As such, the state may only maintain a sampling program along the mainstems of the rivers, and in a few lower stream order systems. The lower order streams are usually sampled just a few miles above the confluence of the larger system. The EPA allows states to consider a wide range of pollutants, including toxins, nutrients, metals, temperature and flow. The states determine what level of pollution in a body of water is acceptable in relationship to established water quality standards. If the system does not meet the established water quality standards it is placed on the CWA section 303(d) list. When a system is placed on the 303(d) list the state is required to create a Total Maximum Daily Load (TMDL) for that river system.

To calculate a load background concentrations and pollution from point sources (ie., factories, wastewater treatment facilities) are determined. The remaining pollution load is attributed to nonpoint sources. There are several flow models in the public domain (eg., ModFlow, HEC, QUAL2E, MMS, SPARROW, SWWM, etc.). The EPA supported program for creating TMDL is Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) an integrated system, which incorporates GIS, national watershed data and modeling tools. TMDL experiences in Oregon and southern California shows that water bodies require site-specific programs for data collection and analysis. For this study it is important to adopt a flow model that is capable of dealing with landscape indicators at the scale of the land use and land cover data. The model must also have the ability to input response indicators such as physical habitat, invertebrate and fish data. This project will review the various flow models and develop an index of which models will work with a set of highly correlated landscape indicators.

The most effective measure of the integrity of a water body is determining the status of its aquatic organisms. Water quality standards are driven primarily by the monitoring of toxicological and chemical indicators. A focus on chemical and toxicology ignores other human impacts on aquatic biota, such as altered physical habitat or flow patterns. Biological monitoring provides information and a response mechanism to the overall health of the watershed, and any chronic impairments from chemical and physical alterations resulting from human activities(Karr and Chu, 1999). Karr and Chu, 1999, describe the success of a biological monitoring program is dependent on "identifying biological attributes that provide reliable signals about resource condition" in relationship to "human actions on biological systems." Human influenced stressors can be manifested as loss of riparian, habitat fragmentation, increase of alien species, excessive water withdrawals as a result of agriculture and urbanization, mining, and logging practices. Modeling of a watershed should simulate the effects of overland flow (ie., surface runoff), stream flow, water depth, temperature, DO, and the fate and transport of potential stressors (ie., sediments, metals, nutrients, etc.) To the aquatic community (Goldstein, 1998). For example surface runoff may erode soil (depending on landscape use and cover), and carry sediment and absorbed constieunts (ie., metals from ARD, phosphate from soils, etc.) to the stream. Kaufmann, et al., 1999, state that the alteration of a watershed can result in excessive transport of sediments into streams, which reduces leads to unstable substrate and a reduction in habitat condition.

Aquatic Biota

For high-gradient streams a comparative analysis for reach indentification will be done between EMAP and RBP protocols. Macroinvertebrates will be sampled using an adapted version of the EMAP protocols (Klemm, et al., 1997) by targeting the more productive riffle habitats. At each sampling site a five-pool/five-riffle reach will be established by moving upstream from the initial Geographic Information System (GIS) site location provided by the EPA until a suitable reach is identified. This reach identification will be compared with the 40 x wetted width reach length of the EMAP protocols. The x-site of the reach location is then recorded with a Global Positioning System (GPS). Riffles, the habitat supporting the richest community of aquatic macroinvertebrates, and pools will be the primary areas sampled. The aquatic macroinvertebrate communities within pools will be sampled, because of their apparent sensitivity to sediment input.

The physical habitat of 3rd and 4th order low-gradient streams change considerably from 1st and 2nd order streams with the substrate in the prior habitat being composed mainly of silt and sand and the latter being dominated by gravel and cobble. In addition, the physical structure of the river channel changes considerably, thus establishing a five pool, five riffle reach may not be possible at 3rd order or larger rivers. If the habitat is found to be relatively homogeneous within higher order rivers with no real defined riffle/pool habitat components the reach will be established as 40 times the stream width. Sampling sites will correspond to the GIS location determined by the EMAP random design. A number of different sampling techniques may be employed for these conditions with possible sampling devices including the Hess, Stovepipe, Eckman, or Ponar samplers. If aquatic macrophytes are found throughout the river length they may also be used as a sampling substrate. The most appropriate sampling technique and the corresponding protocols will be determined following a preliminary investigation of the aquatic fauna and the physical habitat within 3rd and 4th or larger order streams and rivers.

RPB Riffles - Three riffles, within a reach, will be sampled at three locations with a total of nine riffle samples per reach. Locations of the sampling points within each riffle will be determined by first randomly selecting three transects across a riffle. One location along each transect will be determined randomly and a sample corresponding to that location will be taken and preserved individually (three samples per riffle, nine samples per reach). Macroinvertebrate sampling in 1st and 2nd order stream riffles will be conducted using a Hess invertebrate sampler with 500 um mesh net. The Hess sampler will be placed on the substrate in the randomly established location. Cobble and large gravel within the sample area will be rubbed by hand within the sampling device to ensure that clinging invertebrates are removed. The cleaned large cobble and rocks are then removed from the sampling device. The remaining substrate pebbles are dislodged and enter the net. To reduce variability in sampling effort, each riffle sample will be a timed collection over a two minute period. Following collection, the sample will be placed into a #35 standard sieve (500 um mesh) and rinsed to remove fine particulates smaller than 500 um. The remaining sample contents will be grossly cleaned in the field by removing large gravel

and other inorganic material. The samples then will be transferred to a jar and 70% ethanol will be added to preserve the samples.

RBPPool - Macroinvertebrate samples in pools will be obtained by either using a Hess invertebrate, an Eckman dredge sample or a core sampler. The sampling device used will be determined following preliminary investigations of the dominant substrates in the pool habitats of 1st and 2nd order streams in the Humboldt River drainage. Three of the five pools in the sample reach will be selected randomly for sampling. Within a pool, three randomly assigned transects will be established and one location along each transect then will be determined randomly and a sample corresponding to that location will be taken and preserved individuallly (three samples per pool, nine samples per reach). Sample collection methods will vary depending on the method employed. Samples will be preserved with 70% ethanol.

Fish

The objective of the fish assemblage portion of the protocol is to collect a representative sample of the fish assemblage by methods designed to 1) collect all except rare species in the assemblage, 2) provide a measure of the relative abundance of species in the assemblage, and 3) documenting the amphibians collected during electrofishing. A major constraint is to do this sampling within a 4 hour time limit. Data will be summarized, analyzed for correlations among biotic and physical-chemical data, and tested for site differences.

Species Assemblage Assessment

Environmental stress and habitat quality can affect aquatic community structure. Index of Biological Integrity (IBI) methodologies were developed to provide a reproducible method for assessing stream fish community condition (Miller et al.1988; Plafkin et al. 1989). These methodologies may be used to compare relative stream fish community condition on a geographic scale and to assess change over time. IBI uses up to 12 metrics related to fish community taxonomic and trophic structure, fish abundance, and general health, to assess the relative condition of stream fish communities. The application of metrics may be modified for specific geographic regions. It is anticipated IBI methodologies developed for the Sacramento/San Joaquin drainage would be applied in this investigation.

Representative reaches of the North Fork Humboldt River and the reference stream will be isolated and systematically electroshocked to collect fish using the EMAP protocols (McCormik and Hughes, 1997). Methods presented in Kolz et al. (1995) will be followed during electrofishing. During collection, captured fish will be placed temporarily in a 5-gallon bucket during collection then transferred to a live car in the stream. All fish will be identified to species level and counted. To assess population size distribution, up to 50 fish of each species would be weighed and measured (discussed below).

Assessment of Fish Condition and General Health

Environmental stress can affect growth rate and general condition of fish. Condition factors, such as Fulton's condition factor, provide a relative measure of nutritional state or "well being" of individual fish and populations (Anderson and Gutreuter 1983). Such factors may also be used to compare relative condition of populations and to monitor environmental change over time (Ney 1993). Additionally, degraded environmental conditions and a variety of environmental contaminants have been associated with effects to fish health. Such effects may include increased susceptibility to disease, increased parasitism, and teratogenic deformities.

To assess the fish health and general condition, up to 50 fish of each species from each site will be measured, weighed, and assessed for indicators of disease, parasites, and external anomalies. Fish to be assessed will be selected at random. Length and weight data will be used to calculate Fulton's condition factor for each fish and the species for each stream. Methods described in Anderson and Gutreuter (1983) will be used. Examination of external condition of fish will be adapted from procedures provided in Meyers and Barclay (1990) and methods of external fish condition assessment provided in Foott (1990) and Goede and Barton (1987). Fish species, length, weight, and any abnormalities will be recorded on a separate form for each site. All fish, with the exception trout collected for chemical analyses, will be released back to the stream from which they were collected.

Assessment of Teratogenic Effects

The incidence of teratogenesis may provide a reliable indicator of population-level impacts of selenium. Elevated selenium concentrations have been identified in drainage from some mines in northeastern Nevada. Lemly (1997) provided an index which uses information on the incidence of teratogenic deformity and selenium concentrations in whole-body fish to predict effects of selenium on reproductive success and impacts on a fish population. This methodology will be applied to fish species captured in during this investigation.

Up to 50 individuals of each fish species from each stream will be examined for teratogenic deformities using methods described in Lemly (1997). Each individual will be examined for: 1) lordosis, 2) scoliosis, 3) kyphosis, 4) missing or deformed fins, 5) missing or deformed gills or gill covers, 6) abnormally shaped heads, 7) missing or deformed eyes, and 8) deformed mouth. Additionally, each individual will be inspected for bulging of abdomens, bulging or protrusion of eyes, and cataracts; all of which may be indicative of exposure to elevated selenium. Fish species, length, weight, and any abnormalities will be recorded on a separate form for each site. All fish, with the exception trout collected for chemical analyses, will be released back to the stream from which they were collected.

Organosomatic Assays Analyses (Optional)

Up to 10 trout from each stream will be evaluated by an organosomatic assay developed

by Goede and Barton (1987) as modified by Foott (1990). Lahontan cutthroat trout will be collected during electrofishing described above. The initial 10 fish of appropriate size (150 to 250 mm) collected from each stream will be assessed. An organosomatic assay is a method for the ordered observation of gross morphological features of general appearance, morphology of selected organs, hematological parameters, and size criteria and presents a general indication of organism health. For each observational endpoint, a ranking of the severity of impact is established and assigned a numerical value. Each fish is evaluated in terms of the predetermined ranking criteria and the scores are recorded. Blood samples will be collected into lithium-heparinized vacutainer and microhematocrit sample tubes. The blood samples will be centrifuged at 10,000 RPM for 10 minutes for measurement of hematocrit, leucocrit, and collection of blood plasma. Differential leukocyte counts will be performed on "diff-quick" stained blood smears (Stoskopf 1993 as cited in Rice and Schlenk 1995). Blood plasma will be frozen on dry ice and stored at -80°C. Two microbiological assay media (TSA and TYES) will be inoculated with a swab from either the kidney or spleen and incubated at room temperature for 3 days. Isolated colonies will be identified by standard biochemical methods. Kidney or spleen tissue will be prepared for standard virological assays and inoculated (1:20 and 1:100 dilution) onto EPC and CHSE-214 cell lines and held at 15°C for up to 15 days (J.S. Foott, written communication). Liver, gonad, gill, and kidney samples will be collected soon after death, fixed in Davidson's fixative (Humason 1979), transferred to 70% ethanol, processed for 5 Φm paraffin sections and stained with hematoxylin and eosin. Prior to preservation, the maturation stage of ovaries and testes will be visually classified into the six phases described by Hovarth (1986). Samples of liver, gonad, and muscle tissue will be retained for metal and trace element residue analyses. Tissue abnormalities and parasite infections will be analyzed by light microscopy for evaluation of histological effects which may be associated with exposure to environmental contaminants. If tissue damage is observed in hepatopancreas, an aliquot of blood plasma will be tested for the presence of the hepatic injury enzymes alanine aminotransferase (ALT) and asparate aminotransferase (AST). A sample of mid-body muscle tissue will be excised from the remaining carcass and frozen for muscle-lipid content analysis to provide an indication of organism energy reserves (Brown et al. 1993). Organosomatic assays will be performed by Dr. J. Scott Foott in the field. Histological, bacteriological, virological, parasitological, blood chemistry, and enzymological assessments will be performed at the California-Nevada Fish Health Center in Anderson, California under the direction of Dr. Scott Foott.

Toxicity

Sediment provides habitat for many aquatic organisms and is a major repository for many of the chemicals that are introduced into surface waters. Determination of bulk sediment concentrations do not always correlate well to bioavailability, and many factors affect the partioning and availability of chemicals found in the sediment. Contaminated sediments may be directly toxic to aquatic life or can be a source of contaminants for bioaccumulation in the food chain. The object of a sediment toxicity test is to determine whether contaminants in a sediment are harmful to benthic organisms. Surrogate organisms are exposed to sediments under

controlled conditions in the laboratory. Sediment toxicity tests provide direct, quantifiable evidence of biological consequences of sediment contamination that can only be inferred from chemical or benthic community analyses.

Laboratory Procedures

In the laboratory, samples will be placed in a #35 standard sieve and rinsed under tap water for three minutes. Large debris is removed after inspecting for invertebrates to aid in the sorting process. Each sample will be distributed evenly over a subdivided tray and covered with 70% ethanol. Grids within the tray are then randomly selected for sorting order. Using a dissecting microscope, aquatic macroinvertebrates will be removed from each grid in a systematic pattern (left to right movement through the material with the microscope at low power) until 300 organisms are obtained or until the remainder of organisms within the grid are removed. The unsorted portion of the sample will be returned to the jar and will be saved for future use. Aquatic macroinvertebrates will be identified to the lowest possible taxonomic level and placed in a separate vial.

Quality Assurance/Quality Control

To ensure that samples are representative and that data are reliable, accurate, complete, and comparable a quality assurance/quality control (QA/QC) program will be implemented according EMAP QA/QC guidance documents for surface waters (in review) and landscape ecology (in review). QA/QC procedures will be established for field collections, laboratory processing of samples, and data analysis after a preliminary investigation determines the natural variability within the biological systems in the Humboldt River drainage. All samples and data will be collected by trained personnel following the established EMAP protocols.

Aquatic Reference Condition

To assess the condition of aquatic resources within the Humboldt River drainage, reference conditions need to be established for 1st - 4th or larger order streams. Following biological, physical, and chemical assessments of reference sites, it will be possible to make comparisons between reference sites (non-impaired) and other sites by using calculated indices. The following criteria will be used when determining which streams and rivers will be appropriate for establishing reference conditions:

I. Extent of disturbance
- flow regulation
- road construction
- water use including groundwater pumping
- bank damage
- land development

II. Representativeness of streams and rivers in the region sampled

III. Ownership of land and long term status of ownership

IV. Access limitations

A consensus must be reached among biologists and researchers conducting work in the Humboldt River drainage or among those who have previous experience and/or knowledge with reference stream conditions before a reference site is established. Preliminary investigations will also be conducted at potential reference stream sites meeting the above criteria to ensure that appropriate reference sites are chosen.

Reference stream samples will be collected using the same protocols outlined above for collecting site samples. One to three reference streams will be established for each 1st, 2nd, and 3rd order stream category for a total of 3-9 reference streams. Reference streams will be sampled annually for two years.

As a result of large scale disturbance and modification of larger order streams in the Humboldt River drainage and the Great Basin in general, it may be difficult to establish reference conditions for 3rd and 4th or larger order streams. If no reference streams or conditions can be identified, a biological baseline will be established by sampling numerous locations along a stream or river using the obtained information as a baseline. It is likely that no reference stream condition exists for the mainstem Humboldt River. Therefore, ten sites along the mainstem Humboldt River will be sampled annually between the cities of Wells and Lovelock to establish a biological baseline.

Biotic Indices

The following indices will be used to determine the biological condition of aquatic macroinvertebrate communities in perennial streams and rivers in the Humboldt River drainage.

A) EPT/EPT + Chironomid
B) EPT
C) % change in total taxa richness
D) Total taxa richness
E) Hisenhoff Biotic Index
F) Shannon - Weaver Div. Index
G) %Dominant Taxa
H) %Shredders
I) %Filterers
J) %Scrapers
K) %Scrapers/%Scrapers + Filterers

L) %Crustacean + Mollusks

Depending on results of fish assemblage assessment, indices of biological integrity methodologies may be applied. Metrics and scoring criteria are anticipated to generally follow methods developed for the Sacramento/San Joaquin drainage (Miller et al., 1988). The following parameters will be determined at each site where fish are found:

A) % Native Fishes (by number)
B) % Native Species
C) Total Fish Abundance
D) Total Fish Species
E) Number of Salmonid Species
F) Juvenile Salmonid Abundance
G) Catchable Trout (150 mm TL)
H) Sculpin Abundance
I) % of Individuals with Disease, Tumors, Fin Damage, or Skeletal Abnormalities

Potential physical and chemical perturbations within the Humboldt River drainage that may impair the biological system include livestock grazing, agriculture, road construction, timber harvest and mining activities. The biological condition of sampled sites, as measured by the biotic indices, will be compared to the reference stream conditions using EPA Protocol III methods described by Plafkin et al. (1989). The overall assessment of the biological condition will be achieved by summing the metric scores and comparing on a percentage basis the difference between the reference conditions and sampled sites. The biological condition categories are unimpaired, slightly impaired, moderately impaired, and severely impaired. Once the level of impairment has been established, it is possible to determine whether the physical and chemical conditions of a site reflect that level of impairment observed for the metrics. Attempts will be made to devise additional metrics following a preliminary analysis of the first years data. Devised metrics will be tested using the first and second years data to ensure repeatability of results.

Physical Habitat

Physical habitat data will be collected at each site according to the EMAP Surface Water protocols (Lazorchak and Klemm, 1997) . Summary metrics of the habitat data will be generated according to Kaufmann, et al., 1999 (submitted). Collected data will help determine the physical and chemical condition of the streams sampled. Kaufmann (1993) identified seven general physical habitat attributes important in influencing stream ecology. These include Channel Dimensions, Channel Gradient, Channel Substrate Size and Type, Habitat Complexity and Cover, Riparian Vegetation Cover and Structure, Anthropogenic Alterations, and Channel-Riparian Interaction. Anthropogenic influences can adversely affect the physical habitat of streams in many ways (Rankin, 195). Because of the dry arid climate of northeastern Nevada, there is a heavy reliance upon surface and groundwater. This results in considerable water

diversions and extensive groundwater pumping throughout the drainage. Water diversions can impact stream biota in many ways including loss of surface flow, increased water temperatures, unnatural flow regimes, and loss of riparian habitat. Influences of mining, agriculture, livestock grazing, and timber harvest can include alteration of channel morphology, loss of riparian vegetation, elevated water temperatures, high sediment loads, embedded substrate, stream bank instability, and loss of instream and terrestrial cover. A rating scale, for the physical habitat conditions will be modeled after Kaufmann, et al., 1999 (submitted). The following parameters will be measured and compared to reference conditions in order to characterize the physical habitat structure and detect possible impairment of sampled streams (data collected will be qualitative unless noted otherwise):

A) Instream cover
B) Embeddedness
C) Channel alteration
D) Sediment deposition (quant.)
E) Riffle frequency/pool frequency
F) Channel flow (quant.)
G) Depth, width, residual pool vol. (Quant.)
H) Bank Vegetation
    -Characterization
    -Overhead canopy (Quant.-Densiometer)
    -Substrate Composition
I) Bank Stability
J) Riparian Zone Width and extent of Coverage
K) Stream Discharge (Quant.)

Analysis of physical habitat data and corresponding aquatic biota data at a given stream site will enable the investigator to determine the relationships between habitat condition and biological integrity of the streams. In addition, relationships between various aquatic and terrestrial habitat features and aquatic invertebrate taxa will provide further insight into the determinants of aquatic invertebrate community structure.

Stream Sample Reach

Biological and habitat structure measures require sampling a certain distance of stream to get an accurate picture of the ecological community and morphologic characteristics. EMAP protocol require a reach length of 40 times the wetted channel width. The reach 40 channel widths along around our X-site to characterize the community and habitat of our chosen sample point. Upon reaching the site, survey the site according to the following protocol described in Lazorchak and Klemm, 1997. Determine channel width at the X-site by measuring the wetted width across the channel with a surveyor's rod or tape measure at three places considered to be of "typical" width. Scout the sample reach up and down stream to check the condition of the sample reach. The objective of the scouting is to determine if the reach is clear of obstacles. NOTE:

streams less than 4 m wide, use 150 m as a minimum sample reach length (Kaufmann and Robison, 1997). Conditions that may require "sliding" the reach - If a confluence is reached, note the distance and flag the confluence as the reach end. Make up for the loss of reach length by moving ("sliding") the other end of the reach an equivalent distance away from the X-site. Similarly, if the reach runs into a lake, resevoir, or pond. Flag the lake/stream confluence as the reach end, and make up for the loss of reach length by moving the other end of the reach an equivalent distance from the X-site. NOTE: Do not slide the reach to avoid man-made obstacles such as bridges, culverts, rip-rap, or channelization. Starting back at the X-site, measure a distance of 20 channel widths downstream along the side of the stream using a tape measure (be careful not to "cut corners"). At the 20 widths point, find the closest habitat break and flag the location as the start point (transect A). Using the tape measure, measure 1/10 (4 channel widths in big streams or 15 m in small streams) of the required stream length upstream from transect A. Flag the next cross-section or transect (transect B). Proceed upstream with the tape measure and lay out the 9 additional transects at 1/10 of the reach length intervals (transects C-K). Draw a rough map of the stream. Include any interesting features, note any landmarks/directions to be used to find the X-site for future visits.

Habitat Sampling

The physical habitat measurements described in the EMAP-SW field manual (Kaufmann and Robison, 1997) are intended to evaluate the physical properties in wadeable streams. The protocol is most efficiently applied during low flow conditions. It is designed for monitoring applications where robust, quantitative descriptions of reach-scale habitat are desired in a short amount of time. The protocol employs a randomized, systematic spatial sampling that minimizes bias in the placement and positioning of measurements (Hayslip, 1993). Measures are taken over defined channel areas and these sampling areas or points are placed systematically at spacings that are proportional to baseflow channel width (Kaufmann and Robison, 1997). This systematic sampling design scales the sampling reach length and resolution in proportion to stream size. This allows statistical and series analyses of the data (Kauffman, et al., 1999).

The Physical Habitat Protocol consists of six different components: 1. Thalweg - longitudinal survey of depth, wetted-width, habitat class, pool-forming code, bars, side-channels, presence/abscence of soft/fine sediments at 100 to 150 equally spaced points along the sample stream reach, slope and bearing; 2.Subbank - channel morphology class for the entire reach, which includes bankfull widths and depths, incision height, detailed channel and riparian cross-sections, measures of channel cross-sectional wetted width and depth, substrate, percent surface fines; 3. Fish Cover - areal cover class of filamentous algae, aquatic macrophytes, large woody debris, brush/small woody debris, overhanging vegetation, undercut banks, rock ledge and boulder cover and artificial structure; 4. Large Woody Debris - continuous tally of large woody debris along the reach; 5. Densiometer - Lemon model densiometer canopy measurements; 6. measurement of instantaneous discharge, measurements and/or visual estimates of riparian vegetation structure, human disturbance.

Thalweg

The "Thalweg" refers to the flow path of the deepest water in a stream channel. The thalweg profile is a longitudinal survey of maximum depth and several other selected characteristics at 100 or 150 equally spaced points of the stream between the two ends of the stream reach (Kaufmann and Robison, 1997). Data from the thalweg profile allows calculation of indices of residual pool volume, stream size, channel complexity, and the relative proportions of habitat types such as riffles and pools. The EMAP habitat assessment modifies traditional methods by proceeding upstream in the middle of the channels, rather than along the thalweg (Kaufmann and Robison, 1997). Each thalweg depth measurement is taken at the deepest point at each incremental position. The thalweg profile measurements are spaced evenly over the entire reach length such that they are sufficiently close together so as not miss any deep areas and habitat units (Kaufmann and Robison, 1997). Follow these specifications for choosing the interval between thalweg profile measurements:

Channel Width <2.5m	Intervals = 1.0 m
Channel Width 2.5-3.5 m	Intervals = 1.5 m
Channel Width >3.5 m	Intervals = 0.01 (reach length)

Thalweg profile increments at cross-section stations and mid-way between them, the wetted width is measured. As the thalweg is being measured the presence/absence of soft fine sediments is recorded. Soft fine sediments are defined as fine gravel, sand ,silt, clay or muck readily apparent by feeling the stream bed with the fiberglass stadia rod used for measuring the water depth. Mid-channel bars, islands and side-channels are noted to reflect their presence within the reach.

Slope and bearing are measured by backsiting with a clinometer, or bubble level, and a compass downstream between each of the cross-section stations (ie., B and A, C and B, etc.). The overall stream gradient gives an estimate of potential water velocities and stream power. These are important factors for the control on aquatic habitat and sediment transport (Kaufman , et al., 1999). The water surface slope will be used to calculate the residual pool depths and volumes from the multiple width and depth taken during the thalweg measurements (Kaufmann, et al., 1999 submitted). The compass bearing backsites, between cross-sectional stations, will be used to determine the channel sinuosity.

Stream morphologic features are visually classified over the entire reach (Kaufmann and Robison, 1997). At the channel reach level, distinct morphologies may be identified based on sediment transport characteristics, channel roughness configuration. There are six different alluvial channel types defined by Montgomery and Buffington (1993): Cascade (c); Step-pool (SP); Pool-Riffle (PR); Plane-bed (PB); Regime (R); and Braided channel (BC). These 6 categories are applied to the entire reach

Subbank

substrate and channel dimension measurements contribute directly to assessments of habitat volume, channel and stream bed stability, and habitat quality for aquatic resources (Kaufmann, et al., 1999 submitted). According to Kaufmann and Robison, 1997, substrate size and embeddedness are evaluated at each of the 11 detailed cross sections. Substrate size is the most important determinant of habitat character for fish and macroinvertebrates in streams. The substrate influences the hydraulic roughness and consequently the range of water velocities in the channel. It also influences the size range of interstices that provide living space and cover for macroinvertebrates. Sediment characteristics are often sensitive indicators of the effects of human activities on streams (Karr and Chu, 1999). Decreases in the mean sediment size and increases in the percentage of fine sediments will destabilize channels, and also indicates changes in the rates of sediment supply and erosion. In this protocol, substrate size will be evaluated at each of the 11 detailed cross-sections (Kaufmann and Robison, 1997). The basis of the procedure is a systematic selection of 5 substrate particles from each of the 11 channel cross-sections (Kaufmann, et al., 1999 submitted).

At each channel cross-section measurements of the wetted width of the channel and the water depths at each sediment sample point will be taken. If the wetted channel is split by a mid-channel bar, the five substrate points shall be centered between the wetted width boundaries regardless of the bar in between (Kaufmann and Robison, 1997). For dry channels, cross-section measurements will be made across the unvegetated portion of the channel (Kaufmann and Robison, 1997).

Bank morphology measurements contribute to an assessment of channels stability during high flows. These measurements also help make assessments of long-term channel down-cutting and fish concealment features such as undercut banks (Kaufmann, et al., 1999 submitted). Bank angle and undercut distances are measured on the left and right banks (looking down stream) at each of the 11 cross sections. The field crews will also measure the wetted width of the channel, the width of exposed mid-channel gravel or sand bars, estimate incision height (depth), and estimate height (depth) and width of the channel at bankfull stage (Kaufmann and Robison, 1997).

Fish Cover

This portion of the EMAP physical habitat protocol is a visual estimation to evaluate, semi-quantitatively, the type and amount of cover for fish and macroinvertebrates. Metrics are developed according to Kaufman, et al., 1999, assess habitat complexity, fish cover, and channel disturbance. Observations to assess fish cover and several other in-channel features apply to the channel area upstream 5 meters and downstream 5 meters from each of the 11 cross-section stations (Kaufmann and Robison, 1997). The five entry choices for areal cover of fish concealment and other features are "0" (absent - zero cover), "1" (sparse: < 10%), "2" (moderate:

10-40%), "3" (heavy:40-75%), and "4" (very heavy: > 75%). The ranges of percentage areal cover corresponding to each of these codes are the same as for riparian vegetation (Kaufmann and Robison, 1997). Field crews will estimate the areal cover of all of the fish cover and other listed features that arre in thee water and on the banks 5 meters upstream and downstream of the cross-section.

Filamentous algae pertains to long streaming algae that often occurs in slow moving water. Aquatic macrophytes refer plants with stems or roots in the stream that could provide cover for fish or macroinvertebrates. If the stream channel contains live wetland grasses, these are included as macrophytes. Woody debris is referred to as the larger pieces of wood that can provide cover and influence stream morphology. Brush/woody debris pertains to the smaller wood that primarily affects cover but not morphology (Kaufmann and Robison, 1997). The tree or brush within one meter of the surface is the amount of brush, twigs, small debris etc. that is not in the water but is close to the stream and provides cover (Kaufmann and Robison, 1997). Boulders are typically basketball to car sized particles (Kaufmann and Robison, 1997). Many streams have artificial structures in them designed for fish habitat. Streams may also have in channel structures for diversions, impoundment and other purposes (Kaufmann and Robison, 1997). These structures are accounted for as part of the protocol.

Large Woody Debris

The Large Woody Debris (LWD) component of the EMAP physical habitat protocol allows quantitative estimates of the number, size total volume and distribution of wood within the stream reach. LWD is defined as woody material with a large diameter of at least 10cm (4in.) and length of at least 1.5m (5 ft.). All pieces of LWD will be counted if they are at least partially in the baseflow channel, the "active channel" (flood channel up to bankful stage), or spanning above the active channel. Wood not at least partially within those zones is not tallied. LWD in the active channel is tallied over the entire length of the reach, including the area between channel cross sections (Kaufmann and Robison, 1997). Each LWD piece is visually estimated for its length and its large and small end diameters in order to place it in one of the diameter and length categories. The diameter classes are 0.1m to <0.3m, 0.3m to <0.6m, 0.6m to <0.8m, and >0.8m. The length classes are 1.5m to <5.0m, 5m to <15m, and >15m (Kaufmann and Robison, 1997). Sometimes LWD is not cylindrical, so it has no clear "diameter." In these cases visually estimate what the diameter would be for a piece of wood with circular cross section that would have the same volume.

Canopy Cover - Densiometer

Riparian canopy cover over a stream is important not only in its role in moderating stream temperatures through shading, but also as an indicator of conditions controlling bank stability. Organic inputs from riparian vegetation become food for stream organisms. Canopy densiometer measurements are a precise way of quantifying vegetation cover. Vegetative cover over the stream is measured at each of the 11 detailed cross-section stations (Kaufmann and

Robison, 1997). This measurement employ the Convex Spherical Densiometer, model B (Lemmon, 1957). The densiometer is taped to limit the number of square grid intersections to 17 (Kaufmann and Robison, 1997). To take a canopy cover density measurement, the observer looks down on the densiometer held six inches above the water's surface concentrating on these 17 points of intersection. If the reflection of a tree or high branch or leaf overlies any of the intersection points, that particular intersection is counted as having cover (Kaufmann and Robison, 1997). The measure to be recorded on the form is the count (from 0 to 17) of all the intersections with vegetation covering them. A greater number indicates increasing canopy extent and density.

For each of the 11 stations, densiometer measures are taken separately in four directions standing at the center of the stream (Kaufmann and Robison, 1997). These 44 measures will be used to estimate canopy cover over the channel (Kaufmann, et al., 1999 submitted). Canopy measurements are also taken at the left and right side of the stream facing the bank at each of the 11 cross sections. These 22 bank densiometer readings complement the visual estimates of vegetation structure and cover within the riparian zone (Kaufmann, et al., 1999 submitted). These measures are particularly important in wide streams, where riparian canopy may not be recorded by the densiometer standing mid-stream (Kaufmann, et al., 1999 submitted).

Riparian Structure and Human Influence

Riparian vegetation and human influence visual estimation procedures are applied as a semi-quantitative evaluation of these parameters. This assessment is used to evaluate the condition and level of disturbance of the stream corridor and the surrounding area (Kaufmann, et al., 1999 submitted). It also indicates the present and future potential for various types of organic inputs and shading (Kaufmann and Robison, 1997). Observations to assess riparian vegetation apply to the riparian area upstream 5 meters and downstream 5 meters from each of the 11 cross section stations (Kaufmann and Robison, 1997). They include the visible area from the stream back a distance of 10m (30 ft) shoreward from both the left and right banks, a 10m X 10m riparian on each side of the stream (Kaufmann and Robison, 1997). If the wetted channel is split by a mid bar, the bank and riparian measurements shall be for each side of the channel, not the bar (Kaufmann and Robison, 1997).

The riparian vegetation into three layers: a CANOPY LAYER (>5m/15ft high), an UNDERSTORY (0.5m/1.5ft to 5m/15ft high), and a GROUND COVER layer (<0.5m/1.5ft high). Note that several vegetation types (eg. Grasses or woody shrubs) can potentially occur in more than one LAYER (Kaufmann and Robison, 1997). Similarly note that some things other than vegetation are possible entries for the "GROUND COVER" layer (eg. Barren ground). The areal coverage of the vegetation layers is estimated and the type of vegetation (Deciuous, Coniferous, Mixed, or None) in each of the two taller layers (Canopy and Understory) is determined (Kaufmann and Robison, 1997). "Mixed" layer is considered to be more than 10% of the areal coverage if it is made up of the alternate vegetation type (Kaufmann and Robison,

1997).

Areal cover is estimated separately in each of the three vegetation layers. Note: the areal cover can be thought of as the amount of shadow caste by a particular layer (Kaufmann, et al., 1999 submitted). The maximum cover in each layer is 100% so the sum of the areal covers for the combined three layers could add up to 300% (Kaufmann and Robison, 1997). The five entry choices for areal cover within each of the three vegetation layers are "0" (absent: zero cover), "1" (sparse: <10%). "2" (moderate: 10-40%), "3" (heavy:40-75%), and "4" (veryheavy: > 75%) (Kaufmann and Robison, 1997).

The presence and proximity of various types of human land use activities, in the stream riparian area, is used in combination with mapped watershed landuse information to assess the potential degree of disturbance. At each of the 11 cross-sections, the presence/absence and the proximity of 11 categories of human influences: walls/dikes/revetments buildings, pavement, roads/railroads, pipes, landfills/trash, parks/lawns, row crops, pasture/range/hay fields, logging operations, and mining activities (Kaufmann, et al., 1999 submitted). These categories and their proximity to the stream channel are evaluated by the following for the left and right banks:

B - for any and all the items you observe ON THE STREAM BANK
C - for any and all the items that you observe within 10m from the stream bank ("CLOSE")
P - for those items that are PRESENT, but farther than 10m from the bank
O - for those NOT PRESENT

Stream Discharge

Discharge measurements are done at a chosen optimal cross section near the X-site after benthos samples have been collected. Discharge can be measured either before or after electrofishing. In medium and large streams the water depth and velocity (60% of water depth measured from the surface) are measured at 15 equally spaced intervals across one carefully chosen channel cross-section. If using electromagnetic current meter it should be equilibrated to the average stream velocity for 20 seconds.

Periphyton

Periphyton are organic matter associated with channel substrates and are excellent indicators of environmental condition (Lazorchak and Klemm, 1997). Periphyton samples will be collected according to the protocols described in the EMAP Streams protocol (Hill, 1997). Periphyton are algae, fungi, bacteria, protozoa, and associated organic matter associated with channel substrates (Hill, 1997). Periphyton are useful indicators of environmental condition because they respond rapidly and are sensitive to a number of anthropogenic disturbances, including habitat destruction, contamination by nutrients, metals, herbicides, hydrocarbons, and acids (Hill, 1997). Periphyton samples will be collected from the near-shore shallows near the point of collection for the macroinvertebrate kick sample (see macroinvertebrate protocols). The

substrate selected for sampling should be collected from a depth no deeper than can be reached by submerging your arm to mid-bicep depth (Hill, 1997). Periphyton are collected, using the appropriate method, from flowing (riffles) and slack water (pools) habitats (Hill, 1997). Rock and wood samples which are small enough (< 15 cm diameter) and can be easily removed from the stream are collected by placing the substrate in a funnel which drains into a sample bottle. A defined area of substrate surface (12 cm^2) is enclosed, and attached periphyton is dislodged with 30 seconds of brushing with a stiff-bristled toothbrush. Care must be taken to ensure that the upper surface of the rock is the surface that is being scraped (Hill, 1997). Loosened periphyton is then washed, using stream water from a wash bottle, from the substrate into the 500 mL sample bottle (Hill, 1997). Soft-sediments are collected by vacuuming the upper 0.5 cm of sediments confined within the 12 cm^2 sampling ring into a 60 mL syringe (Hill, 1997). All samples, regardless of substrate type, are composited by habitat (riffle or pool) and mixed thoroughly (Hill, 1997). Four subsamples will be taken from each composite sample. These are:

a. Identification/Enumeration
b. Chlorophyll a
c. Ash Free Dry Mass (AFDM)
d. Alkaline/Acid Phosphatase

Sediment Metabolism

Ecosystems are complex units defined by flow rates and physical processes. Functional indicators measure energy flow and material transformation within an ecosystem (Hill,1997). Community respiration is one of the most commonly measured functional attributes of ecosystems and is a sensitive indicator of ecosystem stress (Matthews et al., 1982; Bott et al., 1985; Hill & Gardner, 1987). Niemi et al. (1993) analyzed the ability of several measures of chemical and biological structure and function to detect impact and recovery in stream ecosystems. They found that gross primary productivity (GPP) and respiration (R) were more sensitive to perturbations than most structural measures (Hill, et al., 1997; Hill, et al., 1998; Hill, et al., 1999 submitted). Sediment community metabolism will be collected according to the protocols described in the EMAP Streams protocol (Hill, 1997).

Samples will be collected from the top 2cm of find-grained depositional habitats within cross-sections B-J of the stream reach. The sample will be mixed throughly and sub-sampled into 5 mL screw-top centrifuge tubes (Hill, 1997). Each tube will contain 10mL of the fine-grained sediment composite, and filled to the top with no head space with stream water (Hill, 1997). The tubes are placed into a half-filled ice chest with stream water, or into a dark 'goody bag' placed in the stream, for a 2 hour incubation period (Hill, 1997). One additional tube is added to the incubation chamber to serve as a blank. The Dissolved Oxygen (DO) and temperature are measured at the beginning of the experiment. At the end of the incubation period DO and temperature are measured in each tube including the blank. The water is decanted off from the tubes (Hill, 1997). The tubes are tightly sealed and frozen as soon as possible for laboratory analysis (Hill, 1997).

Chemical Analyses (Water, Sediment, Benthic Invertebrates and Fish)

Note: Some samples, such as filtered water and invertebrates, may be deleted to reduce costs. It is recommend to retain unfiltered water, sediment, and five fish samples per site.

Water and sediment chemistry analysis will be performed primarily in the field with metal analysis of water, sediment, invertebrate, and fish samples being conducted in the laboratory. Water quality and chemistry differences between sites may be attributed to geological differences between watersheds, but can also result from land use practices. Agriculture (input of fertilizers and pesticides), livestock grazing (Nitrogen enrichment), and mining (elevated metal concentrations in addition to low pH) all can profoundly affect the water quality and chemistry of streams. Analysis of water quality and chemistry data on a drainage basis can provide valuable insight into the the effects of differing water quality and chemical conditions on the stream biota and can also provide valuable information on the condition of watersheds within the Humboldt River drainage. The following parameters will be analyzed for all sampled sites.

A) Temperature
B) Dissolved Oxygen
C) pH
D) Conductivity
E) Turbidity
F) Total Suspended Solids
G) Alkalinity
H) Total Hardness
I) Nitrate-Nitrite
J) Total Phosphorous
K) Total Persulfate Nitrogen
L) Ammonia as Nitrogen
Z) Sulfate *(important in mining impacted watershed)*
M) Metals and Trace Elements

Hg	Cu	Ag	As	Mg	Cl
Zn	Fe	Cr	Se	Na	
Al	Mn	Pb	Ca	K	

manganese, arsenic, and selenium are concerns in the area; silver, chromium, and lead may be toxic and may be concerns in some mining districts; aluminum (inorganic monomeric).

Past monitoring has demonstrated that several major and trace constituents of concern are elevated in some streams in northeastern Nevada. Due to the diverse behavior of some of these contaminants in the environment and in biological systems, several sample matrices are required to assess the potential for impacts to the aquatic organisms and habitats. The suite of analytes included under EPA methods 130.2, 160.1, and 300.0 for water and the Contract Laboratory

Program Analytical Services metals methods encompass constituents of concern. The precision, accuracy, and detection limit criteria specified in the Client Request Forms for Contract Laboratory Program analytes have been determined to be adequate for the purposes of this investigation.

Water Chemistry

Water would be collected to assess the mobilization and transport of contaminants, and exposure of aquatic organisms. Because it is assumed that stream water is well mixed, grab samples will be collected to reduce the possibility of sample contamination. Water samples would include filtered water samples for analysis of major ions, which would enable an evaluation of water chemistry and environmental factors affecting water quality. Filtered and unfiltered water samples would also be collected for analysis of dissolved and total trace elements, respectively. This sampling scenario would provide for the evaluation of the chemical form of various contaminants and an assessment of potential exposure pathways of aquatic organisms. Additionally, aquatic life water quality standards for several metals are currently based on dissolved concentrations. Analysis of dissolved and total trace elements in water coupled with chemical residue data in other sample matrices would also enable an evaluation of potential relationships among residue concentrations in various sample matrices.

Unfiltered water samples will be collected from mid-stream from mid-water column depth while facing in an upstream direction. Samples will be collected by immersing a closed certified cleaned polyethylene bottle of appropriate volume then opening under water. Each sample bottle will be rinsed three three times using the above collection technique prior to collection of the sample. Rinsate will be disposed of down stream of the sample collection site. Water samples for trace element (metal) analysis will be collected in 500 ml polypropylene bottles. Filtered samples would be filtered through 0.45 :m acetate filter into 500 ml polypropylene bottles. These bottles would be rinsed at least twice with filtered water. For filtered and unfiltered samples designated as laboratory QC samples, a sample volume of 1 L will be collected. Water samples for major ion analysis will be collected in 250 ml bottles. All water samples would be immediately chilled and shipped chilled to the designated analytical laboratory within 24 hours of collection. To minimize the potential for inadvertent contamination of the sample, samples for metal analyses would be acidified upon receipt by the receiving laboratory.

Water processing equipment (filter apparatus) will be washed with a brush and phosphate-free detergent, rinsed with a dilute nitric acid solution, and triple rinsed with deionized water before and after each use. One field blank and one filtration blank, each consisting of deionized water exposed to sample collection and processing conditions, will be collected. These blanks will be treated as individual samples and submitted for metal and trace element analysis. Additionally, one duplicate water sample and one double volume sample (lab QA/QC) will be collected.

At the fixed stations sites continuous monitoring equipment will be used (e.g., Hydrolab) to measure pH, temperature, DO, etc. An automatic sampler will be used to collect water at timed intervals. At the synoptic sites, water chemistry sample will be collected of stream water to ship to the analytical laboratory, and in situ measurements of specific conductance, dissolved oxygen, pH, and temperature. These samples will be stored in a cooler packed with ziploc bags filled with ice and shipped to the analytical laboratory within 7 days of collection (Lazorchak and Klemm, 1997). Streamside measurements will be made using field meters. The primary function of the streamwater samples and the streamside chemistry measurements are to determine: trophic condition (nutrient status); chemical stressors; and classification of water chemistry type (Lazorchak and Klemm, 1997). Specific conductance, or conductivity, is a measure of the ability of the water to pass an electrical current, which is related to the ionic strength of a solution. Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in solution. Measures of DO and temperature are used to assess water quality and the potential for healthy aerobic organism populations (Hayslip, 1993).

Sediment Chemistry

Sediment would be collected to assess deposition and exposure of benthic organisms to contaminants. Composite samples would be collected to increase the chances of obtaining representative samples of stream sediment. Collection of samples from these sites would enable an evaluation of relationships between trace element concentrations in sediment and concentrations in aquatic invertebrates and fish.

Sediment samples will be collected from areas of fine sediment deposition in pool areas. Sediment samples will include surficial materials (i.e., top 3 cm of sediment) collected with a Wildco model number 2422 H12 core sampler. Each sample will consist of a minimum of 5 subsamples collected within a 10-m reach of stream. Subsamples will be composited in a stainless steel bowl and mixed with a stainless steel spoon. A minimum of 75 g of each composited material will be placed in certified clean 125 ml glass jars with teflon-lined closures. Sediment samples will be stored on ice in the field and transferred to a freezer each evening. Samples will remain frozen before and during shipment to the specified analytical laboratory.

Between each sampling site, all collecting equipment will be washed with a brush and mild detergent, rinsed with a dilute nitric acid solution, triple rinsed with deionized water, and submerged in site water for at least one minute prior to use. During use at the site, an equipment blank will be collected by rinsing deionized water over the equipment after decontamination. The rinsate will be collected and submitted as a water sample for analysis of metals and trace elements. Additionally, one duplicate sediment sample and one laboratory QC sediment sample will be collected from areas of possible contamination.

Benthic Invertebrates

Benthic invertebrates would be collected to determine their accumulation of metals and trace elements and the potential for food chain transfer of contaminants. Invertebrate samples would be collected from the general areas from which sediment samples are collected. Invertebrates will be collected using procedures described in Cuffney et al. (1993). It is anticipated that a Surber sampler will be used to collect invertebrates from riffle and run habitats within the stream. If possible, a single invertebrate family ubiquous to both study streams will be used for residue analysis. The target invertebrate family will be chosen following a survey of each stream. Target invertebrates will be sorted from unwanted debris and placed in certified clean 60 ml-jars with teflon-lined closures in the field. Each sample for trace element residue analysis will consist of a minimum of 5 grams of whole invertebrates. If possible, samples will consist of 10 to 15 grams of whole invertebrates. Invertebrate samples will be stored on ice in the field and transferred to a freezer each evening. Samples will remain frozen before and during shipment to the specified analytical laboratory.

Between each sampling site, all collecting equipment will be washed with a brush and mild detergent, triple rinsed with deionized water, and submerged in site water for at least one minute prior to use.

Fish

Inorganic contaminant accumulation in fish reflects environmental exposure. Tissue residues may be used to evaluate the potential for specific metals or trace elements to adversely affect individual organisms and populations. To evaluate metal and trace element accumulation in fish, five whole fish will be collected from each sampling site. Individual fish will be submitted for analysis of metals and trace elements. If possible, all samples will consist of a single family (i.e., Salmonidae). Trout will be collected by electroshocking (discussed above). Whole fish of appropriate size (150-200 mm) will be placed in plastic bags. Samples will be stored on ice in the field and transferred to a freezer each evening. Samples will remain frozen before and during shipment to the specified analytical laboratory.

Data Analysis

Trace element concentrations will be transformed to common logarithms to improve homogeneity of variance, and geometric means were calculated when a trace element was detected in at least 50 percent of the samples within a given stream and year. A value equal to one-half of the detection limit was assigned to samples for which a specific trace element was not detected. Significance in all statistical tests was assigned at $p < 0.05$.

Two-way analysis of variance (ANOVA) and Tukey's multiple comparison tests will be used to examine relationships among sampling sites for water quality parameters and constituent concentrations in water, sediment, invertebrates, and fish. Two-way ANOVA and Tukey's multiple comparison test will also be used to examine relationships among sites for invertebrate and fish community metrics and measures of fish condition and health. Pearson's chi-square test

will used to examine relationships between trace element concentrations in unfiltered water, sediment, invertebrates, and fish.

Concentrations of major and trace constituents in water generated during this investigation will be compared to applicable State water quality standards and federal criteria for the variety of contaminants evaluated in this investigation. Additionally, concentrations of contaminants in water found at this site will be compared to aquatic life effect concentrations from published literature (i.e., LC_{50}). Concentrations of metals and other trace elements in sediment and tissues will be compared to concentrations associated with adverse effects to aquatic life identified in published literature.

V. DATA MANAGEMENT

After the data has been released by the Principle Investigators it will be permanently stored on the EMAP Surface Water database at the US EPA ORD Laboratory in Corvallis, Oregon.

Data Sharing with EPA, USGS, NDEP, and NDOW

Available data on the water chemistry / water quality, physical habitat and aquatic biota of the Humboldt River drainage will be obtained prior to field sampling from various agencies including the Environmental Protection Agency (EPA), the United States Geological Survey (USGS), United States Fish and Wildlife (USFWS), Nevada Division of Environmental Protection (NDEP), and the Nevada Division of Wildlife (NDOW). Existing fish community data collected by Tom Meier and Pat Coffin - NDOW will be used to supplement presence - absence fish species data in the Humboldt River drainage. USGS has numerous gauging stations within the Humboldt River drainage, in addition to extensive data on the geological formaitons found within Nevada. These data will be useful in relating observed chemical conditions with geological formations in watersheds within the Humboldt River drainage. NDEP has been conducting a water quality monitoring program within 14 hydrographic regions throughout the state. Existing water quality data will be compared with computed biotic indices, and physical habitat data, in order to make a comprehensive assessment of the condition of the aquatic system.

VI. JUSTIFICATION

The Northern Great Basin Ecoregion in Nevada covers an extensive area, yet very little is known of the water quality and associated aquatic invertebrate communities there. Changes in landscape pattern associated with human activities are thought to be the greatest threat to sustaining ecological goods and services derived from our natural environment (Houghton 1994, Ojima et al. 1994). This proposed study will provide a data set that can serve as a basis for evaluating anthropogenic change, and increase basic knowledge of aquatic invertebrate communities in the Basin and Range ecoregion. The expansion of the R-EMAP aquatic bioassessment project in the Humboldt River drainage to encompass the federal lands of

northeastern Nevada will provide further information on the condition of aquatic resources in these areas. The proposed study in conjunction with the overall Nevada R-EMAP project will further assist the State of Nevada in developing and potentially establishing biocriteria throughout the state. Additional information on the ecology of aquatic invertebrates in the Basin and Range ecoregion will also be obtained, with insight into how aquatic macroinvertebrate and fish community structure is affected by various physical and chemical parameters. The large scale investigation will also provide information on the biodiversity of aquatic macroinvertebrates in the northern Great Basin ecoregion of Nevada.

Analysis of status and trends in landscape indicators should significantly enhance the value of "site-level" ecological monitoring activities, such as those being proposed by EMAP and the CENR. Data, such as those derived from satellites, are now or will soon become available for entire regions of the United States at scales relevant to ecological processes (20 to 80 meter resolution). Costs of these data are low when compared to similar spatial coverages acquired from finer-scale monitoring studies. Additionally, spatial data lend themselves to analysis in a Geographic Information System or GIS (Ball 1994). Also, because certain data, such as those derived from satellites, can be composited (in a mosaic) for a large area, landscape analysis can be performed on different spatial units, including natural units such as watersheds and ecoregions and political units such as states, parks, and land-care units. This makes it possible to report landscape statistics at a number of scales for many different types of units and to determine cross-scale relationships between landscape composition and pattern, fundamental ecological processes, and environmental values. Finally, because they can be generated from data that cover an entire region at scales as fine as 30 meters (as opposed to a sample that covers only a small portion of the total area in a region), landscape indicators can provide information not only on the magnitude of problems, but where the problems exist as well. As a result, this information can be used to develop multi-scale plans to reduce vulnerability or risk and prioritize the restoration of ecological function, condition, and sustainability.

Clearly, not all environmental changes relevant to local communities and environmental managers can be detected through changes in landscape features from satellite imagery (O'Neill et al. 1997). Many pollutants or the replacement of native wildlife with introduced species may cause little or no change in landscape composition or pattern. To achieve a complete assessment across many scales within a region, landscape indicators must be integrated with monitoring at the "site"and "community" levels (Jones and Riddle 1996). This is one of the primary challenges of Federal agencies conducting multi-scale environmental monitoring and assessment.

An analysis of spatially explicit landscape change over the past 30 years would assist us in identifying those areas of the country where water resources are most vulnerable to landscape changes. It would also help us target specific areas where restoration or protection would yield the greatest reduction in risk. However, we currently lack a comprehensive approach to conduct an assessment of this nature and magnitude.

Such an approach requires the development of landscape indicators that capture ecological and hydrological important aspects of landscape change and that can be generated from digital maps of biophysical characteristics. It also requires development of spatially distributed models to interpret how landscape changes influences risks to sustainable water resources. Although considerable progress has been made in developing landscape indicators and models (see Jones et al. 1997), the current state of science in landscape indicators and models prevents implementation of such an approach nationally.

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VIII. PROPOSED BUDGET

Budget Categories	Year1	Year2	Total
A. Salaries			
1. Senior Personnel			
Robert K. Hall 25% in kind	15,000	15,000	30,000
Daniel T. Heggem 10% in kind	6,000	6,000	12,000
John Hillenbrand 10% in kind	6,000	6,000	12,000
Peter Husby 25% in kind	15,000	15,000	30,000
Peter Tuttle 25% in kind	15,000	15,000	30,000
2. Other Personnel			
Postdoctoral Associate			
Graduate Assistant	10,000	10,000	20,000
Hourly Assistants	15,000	15,000	30,000
Total Salaries	25,000	25,000	50,000
B. Fringe Benefits	N/A		
C. Total Salaries and Fringe Benefits	25,000	25,000	50,000
D. Equipment			
Total Equipment	25,000	25,000	50,000
E. Travel			
1. Meetings (planning and science)	5,000	5,000	10,000
2. Field Work	10,000	10,000	20,000
Total Travel	15,000	15,000	30,000
F. Other Costs			
1. Materials and Supplies			
Field	1,000	1,000	2,000
Lab			
Periphyton	12,000	15,000	27,000
Water Chemistry	15,400	19,250	34,650

Sediment chemistry	7,200	9,000	16,200
Benthic Invertebrates	6,600	8,250	14,850
Fish tissue	6,600	8,250	14,850
Total Laboratory	48,800	50,750	99,550
2. Publication Costs	0	500	500
3. Consultant (peer review)	0	1,000	1,000
4. Computer Time (in-kind)	6,000	6,000	12,000
5. Contracts (in-kind)	30,000	0	30,000
6. Other			
Maintenance of equipment	2,000	2,000	4,000
Total Other Costs (in-kind)	44,000	15,500	59,500
G. Total Direct Costs (A through F)	113,800	115,750	229,550
H. Total Indirect Costs (15%) N/A			
I. Total Direct and Indirect Costs	113,800	115,750	229,550

Itemized Budget

Landscape

Provided as in-kind NERL-LV Landscape Ecology under A-1

Flow Models

Provided as in-kind NERL-LV Landscape Ecology, USEPA Region IX under A-1, University of Arizona and University of Nevada Reno under category A-2

Aquatic Biota - ID work to be done by graduate students category A.2

Analysis	Cost/Sample	Cost/Sample/Group	Number of Samples	Extended Cost
ID	$100	$100	Year 1 - 40 Year 2 - 40 + 10 re Year 3 - 40 + 10 re Year 4 - 40 + 10 re	$4000 $5000 $5000 $5000
		Total Cost	Year 1 & 2	$ 9,000

Year 3 & 4		$10,000
		$19,000

Toxicity

Provided as in-kind USEPA Region IX laboratory under category A-1.

Physical Habitat

Provided as in-kind NHERL-Corvallis, USEPA Region IX under A-1.

Periphyton

ID, chl a, biomass, some limited enzyme activity and sediment respiration. NHERL - Cincinnati.

Analysis	Cost/Sample	Cost/Sample/Group	Number of Samples	Extended Cost
ID	100	$300	Year 1 - 40	$12,000
Chl-a	80		Year 2 - 40 + 10 re	$15,000
Biomass	60		Year 3 - 40 + 10 re	$15,000
Sed Resp & Enz	60		Year 4 - 40 + 10 re	$15,000
		Total Cost	Year 1 & 2	$27,000
			Year 3 & 4	$30,000
				$57,000

Chemical Analyses

Water Chemistry - USEPA Region IX Laboratory

Analysis	Cost/Sample	Cost/Sample/Group	Number of Samples	Extended Cost
ICP Metals	60	$180	Year 1 - 40	$7200
GFAA Metals	70		Year 2 - 40 + 10 re	$9000
Mercury	35		Year 3 - 40 + 10 re	$9000
Hardness	15		Year 4 - 40 + 10 re	$9000
Anions	50	$205	Year 1 - 40	$8200
Alkalinity	20		Year 2 - 40 + 10 re	$10250
Ammonia	35		Year 3 - 40 + 10 re	$10250
TKN	40		Year 4 - 40 + 10 re	$10250
Total Phosphorus	35			
TSS	10			
TDS	10			
		Total Cost	Year 1 & 2	$ 34,650
			Year 3 & 4	$ 38,500
				$ 73,150

Sediment Chemistry

Analysis	Cost/Sample	Cost/Sample/Group	Number of Samples	Extended Cost
ICP Metals	60	$180	Year 1 - 40	$7200
GFAA Metals	70		Year 2 - 40 + 10 re	$9000
Mercury	35		Year 3 - 40 + 10 re	$9000
Hardness	15		Year 4 - 40 + 10 re	$9000
		Total Cost	Year 1 & 2	$ 16,200
			Year 3 & 4	$ 18,000
				$ 34,200

Benthic Invertebrates

Analysis	Cost/Sample	Cost/Sample/Group	Number of Samples	Extended Cost
ICP Metals	60	$165	Year 1 - 40	$6600
GFAA Metals	70		Year 2 - 40 + 10 re	$8250
Mercury	35		Year 3 - 40 + 10 re	$8250
			Year 4 - 40 + 10 re	$8250
		Total Cost	Year 1 & 2	$ 14,850
			Year 3 & 4	$ 16,500
				$ 31,350

Fish

Analysis	Cost/Sample	Cost/Sample/Group	Number of Samples	Extended Cost
ICP Metals	60	$165	Year 1 - 40	$6600
GFAA Metals	70		Year 2 - 40 + 10 re	$8250
Mercury	35		Year 3 - 40 + 10 re	$8250
			Year 4 - 40 + 10 re	$8250
		Total Cost	Year 1 & 2	$ 14,850
			Year 3 & 4	$ 16,500
				$ 31,350

IX. APPENDICES

Appendix A – Quality Assurance Project Plan

Appendix B - Monitoring Manual for Grassland and Shrubland and Savanna Ecosystems

Appendix C – Soil sampling protocol

Appendix D – Sediment sampling protocol

Appendix E – Water Quality sampling protocol

Appendix F – Fish sampling protocol

Appendix G – Macroinvertebrate sampling protocol

Appendix H – Physical sampling protocol (e.g., Proper Functioning Condition, Rapid Habitat Assessment)

Appendix I – EMAP Stream Sampling protocol for targeted habitat